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ANNALS *of* SURGERY

Vol. XCVII APRIL, 1933 No. 4

EFFECTS OF SYMPATHETIC NERVE SURGERY IN CERTAIN INTESTINAL CONDITIONS *

By Frederick S. Wetherell, M.D.

of Syracuse, N. Y.

The anatomy of the sympathetic nervous system has been carefully studied and is probably, at the present time, as definitely established as the anatomy of other parts of the body. It is, undoubtedly, true that many operations on the sympathetic system in the past have resulted in failure because of the indefiniteness of both the anatomical and physiological features pertaining to these nerves. It is probably because of these failures that this type of work fell into disrepute for some years following the beginning work of some of the early investigators. However, much advance has been made in the past decade by research of both foreign and American workers.

The sympathetic nervous system, it is well known, carries impulses which concern not only smooth muscle activity, but also the transmission of pain. In the present communication we are limiting ourselves to a consideration of the action on certain smooth muscle fibres; *viz.*, those of the internal rectal sphincter and lower colon.

The results of the excision of the superior hypogastric plexus (pre-sacral nerve) show quite definitely that impulses are transmitted through this plexus, which maintain the tone of the internal rectal sphincter. Releasing the tonicity of the sphincter allows the fecal mass to come down and thus impinge on the external sphincter, which is under voluntary control. The stimulus of the mass in this area is readily perceived by the patient, and by immediate response on his part, a regular bowel habit is gradually acquired. This is, undoubtedly, the modus operandi by which the end-results are obtained in that group of cases, the outstanding feature of which is an inability to have regular defecations, resulting in gradual and repeated filling of the colon with fæces, to the point of impaction. The feature of impaction is noted most constantly in both Hirschsprung's disease and severe rectal obstipation.

The satisfactory results obtained by Adson and Learmonth, in the treatment of Hirschsprung's disease, first by excision of the lumbar ganglia, and later by resection of the pre-sacral nerve fibres, alone bear evidence to the fact that the internal sphincter contractility is thereby definitely lessened. It was their work which prompted us to attempt this operation in Hirschsprung's disease. Later, following a report of Rankin and Learmonth[1] of

* Read before the American Association of Obstetricians, Gynecologists, and Abdominal Surgeons, September 12, 1932.

a case of severe, chronic, rectal type of obstipation, greatly benefited by presacral neurectomy, we were again prompted to try the method in one of these cases. They report one case and describe the technic. Theirs, and one reported by Flothow,[2] are the only cases we have been able to find reported in the literature.

Feeling, as we did, that a long enough time, at least a year, should elapse before end-results could be reported which would be of any value, we have waited until now to cite the two cases reported herewith. Although the report of two cases does not, by any means, constitute a so-called series, the fact must be taken into consideration that the number of cases of this type, presenting themselves for treatment, while not rare, is, nevertheless, not common. Furthermore, the results obtained seem to justify the report. We feel, too, that it is quite possible that more cases of the constipation type may present themselves, when the fact is better known to the profession that there is hope for relief after other methods have failed. We have recently operated upon another case of Hirschsprung's disease, but it is, as yet, too early to report the final result. The patient, a boy of eight years, operated upon August 29, 1932, has had daily bowel movements without enemas or cathartics, to date, September 30.

Case XI.—*Hirschsprung's Disease* (*Megacolon*).—A female child, eight years of age, was admitted to the pædiatric service of Syracuse Memorial Hospital May 14, 1930. She was suffering from typical Hirschsprung's disease. The abdomen was greatly distended and peristaltic waves were visible. X-ray examination showed an enormously dilated colon. The child's mother was of a poor mental type and her father was a drunkard. Since babyhood the mother had noticed that the child often experienced considerable difficulty on defecation. Hard masses of fecal material caused a great deal of pain in passing—so much so that the child began to avoid having bowel movements. After a time this necessitated calling the family physician, who was obliged to remove impacted fecal material by manual means about every five weeks. After the lower bowel had been thoroughly emptied, fair results were obtained by enemas for a time. All attempts to establish regularity of defecation, however, were of no avail. This meant repeated manual emptying of the bowel and a number of trips to the hospital—she was admitted to this hospital four times during the year 1929. The child had a definite neurasthenic makeup, was undernourished, and very much under size. Even though the mother was able to obtain fairly good results with enemas, at times, the regularity of the treatment was interrupted by the necessity of her leaving home to work, due to the father's state of chronic inebriety. These facts are mentioned to give a picture of the child's environment and temperament, and bear directly on the end-results of the operative procedures for attempted relief of the pathological condition. A left, lumbar, sympathetic ganglionectomy and ramisection of the second, third, and fourth lumbar ganglia was performed May 26, 1930. The child's recovery was uneventful, and she was allowed out of bed on the seventeenth day. Oil enemas were given beginning the third day after operation, and one-half ounce of mineral oil was given by mouth, night and morning, beginning the fourth day. Bowel movements were regular following this treatment and after twenty-six days it was discontinued. She remained in the hospital five weeks, and her bowels moved every morning before rounds were made. The promise of a dime in the event that this happened was, probably, of assistance in obtaining this result. The child was discharged in excellent condition. She was readmitted in November, 1930, and again in January, 1931. Each of these times the colon was full but was easily emptied, and while in the hospital daily movements were again obtained. Because of her work, the mother had been unable to carry out instructions, and the child had been left very much to her own resources. September 24, 1931, she was again admitted, and this

time, because not all of the motor fibres of the internal sphincter are severed by the removal of the second, third, and fourth ganglia, the proposition that the superior hypogastric plexus should be removed, was taken under advisement. It was felt that, probably, if this were done, all tone impulses then being blocked, a permanent result might be obtained, despite the difficulty of proper supervision at home. This operation was performed October 22. The descending colon was found to be practically normal in size —the transverse, somewhat larger. Oil enemas were given for four days and mineral oil by mouth throughout the child's stay in the hospital. Daily bowel movements were again obtained, and she was discharged after an uneventful recovery November 7. She was sent to a children's convalescent camp. There she reported to the supervisor that her bowels moved daily. No direct check was made on this statement. In April, 1932, she was again admitted to the hospital with the descending colon filled with fæces. Emptying was easily effected by colonic irrigation. Close questioning revealed the fact that the child had a constant fear that she might have pain when her bowels moved. The beginning of this fear was traced back to the many times that painful manual extraction had been performed. Much reassurance and checking on bowel action was finally resulted in the establishment of a regular habit, which has now been in effect for over five months.

Case II.—*Severe Rectal Type of Obstipation.*—H. F., male, age forty years, a priest, was admitted to St. Joseph Hospital, Syracuse, N. Y., February 1, 1931. His chief complaint was a severe, chronic obstipation, with nausea, anorexia, and general weakness. This obstipation was of twenty-two years' duration despite numerous sojourns in hospitals and clinics for treatments, and surgery, in attempts to correct the condition. If no attempts were made to obtain a movement by means of enemas or cathartics he would go ten to fourteen days without a defecation. After a time even these expedients were often of no avail. A feeling of fulness in the left side of the abdomen developed during this period of filling of the terminal portion of the bowel, and he would have attacks of nausea, sometimes vomiting, and a general feeling of malaise and anorexia. He never had difficulty in passing gas. There was a gradually increasing difficulty in his ability to attend to his priestly duties. Because of his voluntarily restricted diet, his general strength was at low ebb. His first hospitalization was in 1920, at which time his appendix was removed because of the recurrent attacks of nausea and vomiting. His condition was not improved following the operation. In fact the obstipation grew increasingly worse. He was readmitted in 1922, and during a two-weeks' period of observation he was given a series of colonic irrigations. His bowels had not moved for six days previous to his admission. He was relieved of his distress, but the relief was short-lived, the entire sequence of events recurring after his discharge from the hospital.

In 1929, he again entered the hospital, and a gastro-intestinal röntgenographical study was made. This resulted in negative findings. He left the hospital at the end of a week, unimproved. Shortly thereafter he went to a clinic in the mid-west for examination and treatment. He was given a special diet, and told to increase his physical activities. After a three-weeks' stay he returned home somewhat improved, but despite observance of the diet, there was a gradual return of the obstipation. There was a marked increase in nervous instability, anorexia, and inability to work. His insistence that something be done for him, and the thought of his family physician that there might be a lower sigmoid obstruction, caused by adhesions, was the reason for his admission at the time we first saw him. He was emaciated. There was a slight acneiform eruption on the face. The thyroid gland was normal in size, easily palpable. There was a course tremor of the hands. A basal metabolic test showed a rate of minus 17.4 per cent. At the time of the test his pulse was 56. These findings, along with lack of strength, and general nervous instability, place him in the group of "chronic nervous exhaustions," easily explainable, when the entire foregoing history is taken into consideration. There was a sausage-shaped mass in the left lumbar and left iliac regions of the abdomen, presumably fecal material in the descending colon and sigmoid. It disappeared after colonic irrigation. A barium enema showed a slight hyperperistalsis of the descending colon. Proctoscopical and sigmoidoscopical examinations revealed no

gross pathology. February 11, 1931, a left lumbar ganglionectomy and ramisection of the second, third, and fourth ganglia was done. He had a stormy convalescence, occasioned by hiccoughs, lasting seven days. On the thirteenth day after operation he was allowed to be out of bed, and he had two defecations without the aid of enemas. Mineral oil, one ounce, was given night and morning. From then on, until the present time, at first for three months with the assistance of mineral oil, and since then unaided, there have been one or two defecations a day. No particular attention is being paid to the diet; there has been a forty-pound gain in weight; and there is a complete change in the patient's outlook on life. An important phase in the after care of this case was the repeated assurance that there was no reason why regular bowel movements should not continue, and that a regular full diet should cause no difficulties.

In both these cases the point was stressed that a bowel habit with movement after breakfast was of utmost importance, and in each case this is now taking place with clocklike regularity.

SUMMARY.—Despite the headway which has been made in the past decade along the lines of research and practical application of the results of studies on the sympathetic nervous system, one is often amazed at the diversity of reports of end-results in patients operated upon for like maladies, and presumably, if the operator is to be believed, a technic not varying in the least.

Like so many advances in the science of medicine, the method of trial and error has prevailed in sympathetic nerve surgery, with a gradual narrowing down of the indications, and the usual moderation of initial enthusiasm. When considering this type of surgery and its end-results, one thing, it seems, must be kept in mind constantly, and that is that each sympathetic nervous system is a part of a particular individual. The entire makeup of the person suffering from a difficulty which can, at least in part, be traced to this system, is usually, to a greater or lesser degree, one of nervous instability. Common examples of these types are the hyperthyroid individual, or the one with Raynaud's disease. One must not forget that the higher centres are minutely inter-related with the activities of the sympathetic nervous system as exemplified, for instance, by the vasodilatory, and the pilomotor activities during fright. Outside influences filter through the sensorium and react, sometimes very rapidly, on the sympathetic system, and one of these outside influences is the attitude of the attending physician. By this we mean that the surgeon attempting this type of work, and expecting good results, must have a full understanding of the makeup of his patient. He must be willing, not alone to perform the operation, but thereafter, to closely follow the patient, using all of the applied psychology at his command. He is dealing with a type of individual which demands this sort of postoperative care almost more than any other. The fear of the patient that the chronicity of the affection under treatment may not be modified is, in our experience, an outstanding factor. Repeated reassurance, therefore, is of paramount importance.

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THE SURGERY OF THE SYMPATHETIC NERVOUS SYSTEM

OPERATIVE NOTES BASED ON 273 OPERATIONS

By Steele F. Stewart, M.D.

of Los Angeles, Calif.

The surgery of the sympathetic nervous system is unknown to and feared by most surgeons. The arrangements of the sympathetic fibres, however, simplify greatly the surgical problem, but likewise produce effects other than the ones sought. Thus the cervical ganglia receive their cerebral influences through the white rami of the first five or six dorsal nerves, transmitting the stimuli by gray rami to the eye, salivary glands, heart, bronchi, the sweat glands, erector pilæ and blood-vessels of the arm, neck and scalp of the same side. It is therefore patent that a section of the sympathetic trunk below the first dorsal nerve and ascending rami of the first dorsal nerve will produce maximal effects in the organs and areas indicated, so far as the removal of central control of the sympathetic is concerned; however, it would not remove any sympathetic ganglionic autonomy, if such exists. In like manner, the central sympathetic influences to the hind quarters enter the sympathetic chain from the sixth dorsal to the upper lumbar segments, and are redistributed by gray rami to the lumbosacral plexus chiefly from the second lumbar downward. Hence a section of rami from the second lumbar to the fourth lumbar, and of the trunk below this level, would produce maximal effects in the lower extremities with associated effects on pelvic viscera.

Between 1925 and December 31, 1931, we have operated 273 times in connection with this system, and certain surgical lessons are outstanding. These notes are written to make the surgery of this system more understandable.

In 1923 and 1924, Royle[6] described approaches to the lumbar sympathetic trunk and brachial rami. The transabdominal approach,[1] with reflection of the peritoneum from beyond the cæcum or sigmoid to the mid-line, we feel is an unnecessary entry of the peritoneal cavity attended by shock and a risk of ileus immediate and remote, and its very magnitude and location open the way for potentially enormous post-operative hernia, and hence it has been rejected as unsound surgically and physiologically.

Lumbar Operation.—The original approach of Royle is entirely adequate for any surgery on the lumbar sympathetic trunk. It centres around the trigonum lumbale and consists of an angular incision from the eleventh rib to the trigonum lumbale and along the iliac crest for six to eight centimetres. The patient's body is best rolled toward the opposite side through an angle of 45° to 60° and the loin put on stretch. Carrying the incision down to the iliac crest and the lumbar muscles it is advisable to bluntly dissect the outlined flap well forward and to loosen the posterior and inferior margin of the

incision in order to secure an adequate exposure. In most cases the trigonum lumbale is easily distinguishable, but occasionally one muscle layer blends into the next without any line of demarcation. This has occurred bilaterally and has necessitated a direct myotomy from the eleventh rib to the crest of the ilium. The external oblique is raised on a blunt dissector and divided close to the iliac crest. The internal oblique is reflected in the same way. In this dissection superficial nerves are frequently found and cut, but their division leaves only a sense of numbness below the area of operation.

In most individuals a muscularis transversalis can be definitely identified, although in a fair number of individuals only a dense fascia is recognizable. This fascia is cut or broken through well posteriorly and is opened to the full extent of the incision. Henceforward the operation is carried on by blunt

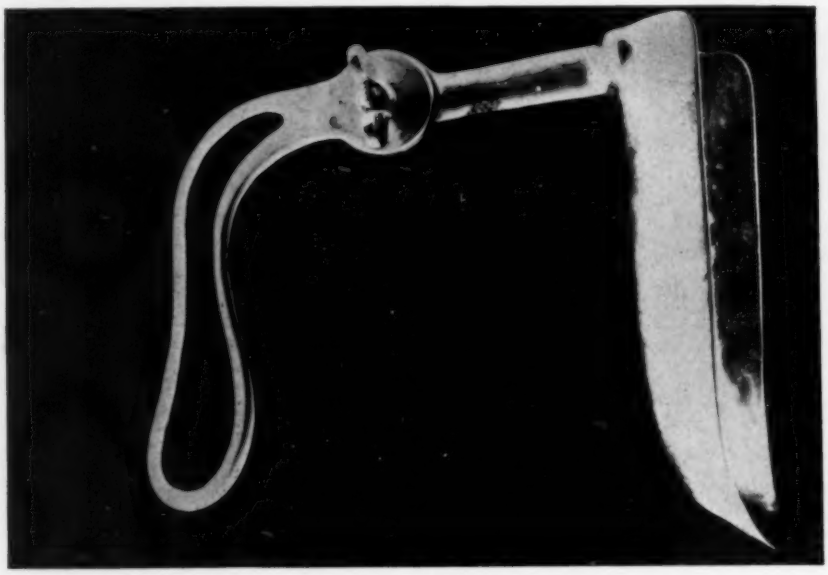

FIG. 1.—Peritoneal retractor of Royle's. The handle is detachable, and there are four sizes of spoons for various sizes of patients.

dissection. The peritoneum is pushed forward from its attachment to the posterior abdominal wall, carrying with it the ureter.

As the sympathetic trunk lies anterior to the psoas muscle, it is important to remember that the psoas rises abruptly from the posterior abdominal wall to the height of the vertebral body. One should guard against dissecting between the psoas and the posterior muscles which would lead one into the region of the transverse processes.

Retractors are useless until the intervertebral discs are felt. Those designed by Royle are most satisfactory. (Fig. 1.) They are made in several sizes, and if one is doing a large volume of work all sizes will be required. The spoon retractor stretches the peritoneum forward exposing the ureter attached to its posterior surface. The surface of the psoas is cleared of areolar tissue revealing the tendon of the psoas parvus and ilio-inguinal nerve.

Twice the tendon of the psoas parvus has arisen high above the magnus barring all advance. Its division has given no subsequent difficulty.

The psoas retractor (Fig. 2A) of Royle is most effective in rolling the psoas out of the road exposing the spino-psoas sulcus filled with a triangular mass of glandulo-areolar tissue. It is useless to search this mass for the sympathetic trunk as the latter lies directly on the spinal ligaments. Bluntly reflecting this small mass of tissue anteromedially, the trunk of the sympathetic can be felt or seen on the left side lying external to the aorta. On the right side a much more delicate situation obtains for the sympathetic trunk lies beneath the vena cava. This requires most careful dissection, not only because of the proximity of the vena cava, but because in about 5 per cent. of patients one or more vertebral veins overlying the sympathetic connect

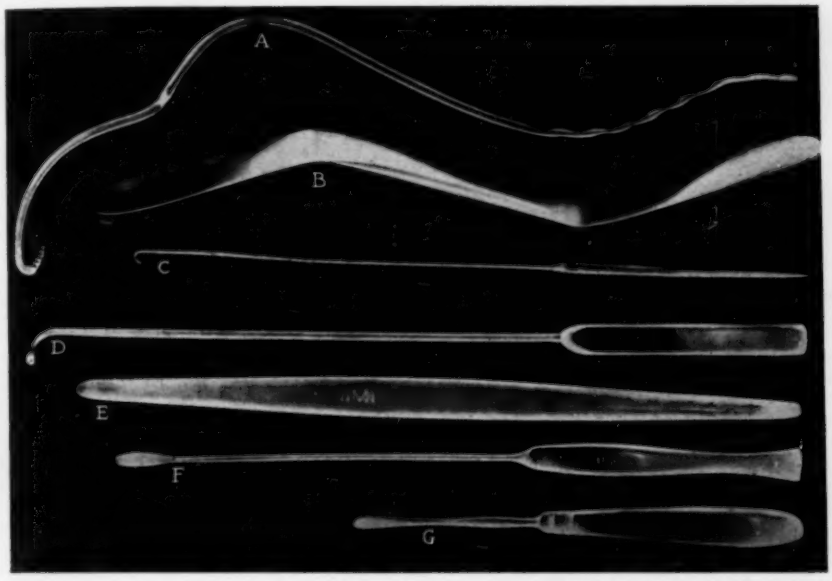

FIG. 2.—Instruments to be numbered from above downward A, B, C, D, E, F, G. A—Psoas retractor of Royle's. B—Double-ended spoon reflector for use in cervical operations. C—Small hook used in picking up sympathetic. D—Large bulb end hook used in holding abdominal trunk. E—Blunt dissector of Royle's. F—Long slender dissector used in isolating sympathetic trunk in both lumbar and cervical operations. G—Short dissector used in superficial tissues of the neck.

immediately with the vena cava. These veins bind down the sympathetic trunk and rami usually accompany the vertebral vessels.

The sympathetic trunk is secured by a slender, sharply curved, blunt hook (Fig. 2C); the end of the hook should be directed backward. Once secured a large ball-ended flat hook (Fig. 2D) is inserted in a reverse direction, lifting the ganglionic chain and depressing the great vessels. Once secured there is little cause for confusing its identity, for, regardless of location of the sympathetic, one is impressed with its tautness, tautness such as one would encounter in lifting the string of a violin.

The ganglia are not distributed with mechanical precision. In the majority of patients they follow the text-books quite closely. However, in about 5

per cent. of patients one finds an arrangement similar to the cauda equina, the trunk descending to a massive ganglion in the region of the second and third lumbar vertebræ when a veritable sheaf of rami extend distally. In a similar number the lower portion of the chain appears as a fine filament, the rami coalescing into one enormous ramus. Hence, if the ganglionic chain cannot be identified below it should be sought higher up.

The upper level of dissection is recognized by the direction of the rami. The middle and lower rami in their general direction proceed caudad and dorsally; at the level of the second lumbar the rami pass cephalad and dorsally and there is usually one large ramus present at this level.

Beside the rami which pass between the spine and psoas, other rami pass toward or beneath the great vessels and may be visceral or commissural rami communicantes. These intercommunicating rami may determine some of the contralateral effects described by Orbeli[5] in his Hertzstein lectures. All rami are avulsed, leaving the chain free of lateral connections.

It is sometimes possible to mobilize all the ganglia and rami before dividing any; again it will be necessary to avulse each ramus before securing another. If overlying veins are found an accompanying ramus is almost surely to be found, the trunk is divided and carefully drawn from beneath the vertebral vein. Which rami are to be divided depends on the operative indication and does not come within the scope of this paper. In all cases the trunk should be severed as low as possible. The ganglionic chain may be removed or not according to caprice, but no better results are obtained by ganglionectomy than by thorough ramisection and trunkotomy.

Royle[8] found it inadvisable to do both lumbar operations at one sitting. This operation may be exasperatingly long or surprisingly brief. Our own records show that the time varies from seventeen minutes to one hour and fifty minutes, the longer time occurring in the earlier cases or larger individuals of the series. In children the present average is twenty-five to thirty minutes, and in adults fifty to sixty minutes. Severe bleeding has never been experienced, little shock has resulted, hernia have not followed, and no deaths have occurred in 174 operations.

Operations on the Dorsocervical Sympathetics.—Royle[6] originally described a division of the sympathetic rami as they passed from the scalenus anticus to the brachial plexus. This operation did not give us satisfactory results as obtained in the lumbar operation, and Royle subsequently described a division of the sympathetic trunk between the first and second dorsal roots, which placed the brachial results on a par with lumbar ramisection. Royle's dorsal trunkotomy[7] was an extension of the old brachial ramisection. Henry,[3] in 1927, described a posterior approach to the sympathetic trunk by a resection of the transverse processes and a portion of one or more ribs. We tried both methods, and have entirely discarded the posterior approach as extremely shocking, more difficult of performance, and inferior in results. In spinal anomalies it is almost impossible to orient one's self by the approach

of Henry. However, the trunkotomy of Royle is exacting to the most experienced.

The incision extends obliquely slightly upward and backward from the inner end of the clavicle for six to eight centimetres, rarely the subclavian vein lies immediately beneath the incision. The external jugular vein and platysma are divided in the line of incision. The sternocleidomastoid is divided, in whole or in part, revealing the omohyoid which is retracted upward. A layer of fat is next encountered, divided bluntly and retracted, revealing the shiny white brachial plexus coming from behind the scalenus anticus on which lies the phrenic nerve. The phrenic and the fifth nerves are connected higher up in the neck, but we have never divided this inosculation.

With the patient lying almost flat on his back, it is easy to lose one's

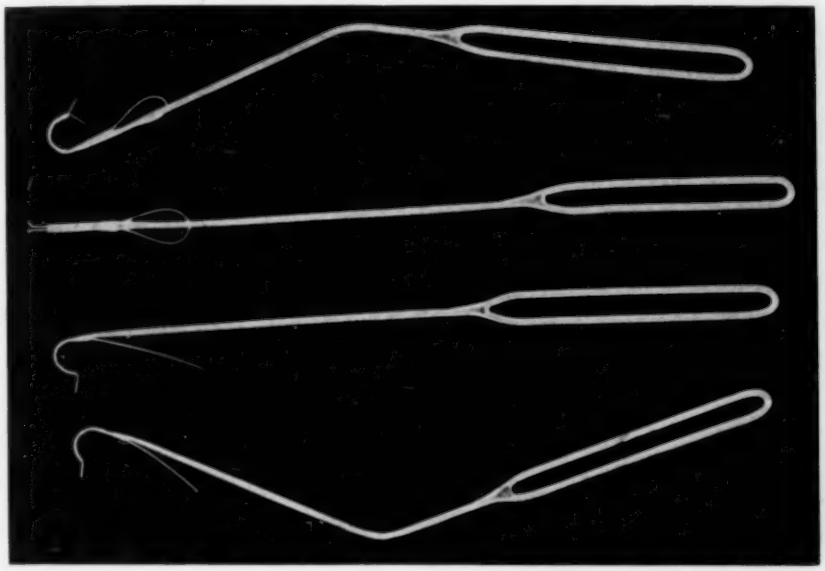

FIG. 3.—Curved ligature carriers, single and double with wires threaded through the curved needles.

sense of direction and dissect against the spine when the general axis of dissection should be downward toward the thoracic cavity between the scalenus anticus and the plexus. While doing this dissection one encounters very tough fibres passing from the posterior surface of the scalenus into the face of the nerve roots. These are the sympathetic rami and are not nearly as sizeable as Royle figured them in his Murphy Oration of 1924.[6] These may be avulsed if necessary.

Immediately overlying the brachial plexus one finds the transverse cervical artery and vein. These may be tied and divided. Usually between the seventh and eight cervical roots one encounters the deep cervical artery and vein. This artery is very difficult to tie because of the short length of trunk exposed. To facilitate this ligation a special aneurism needle has been made

by fastening a blunted and bent eighteen-gauge hypodermic needle to a handle: through this the ligature can be passed directing the end of the ligature directly into one's forceps. (Fig. 3.)

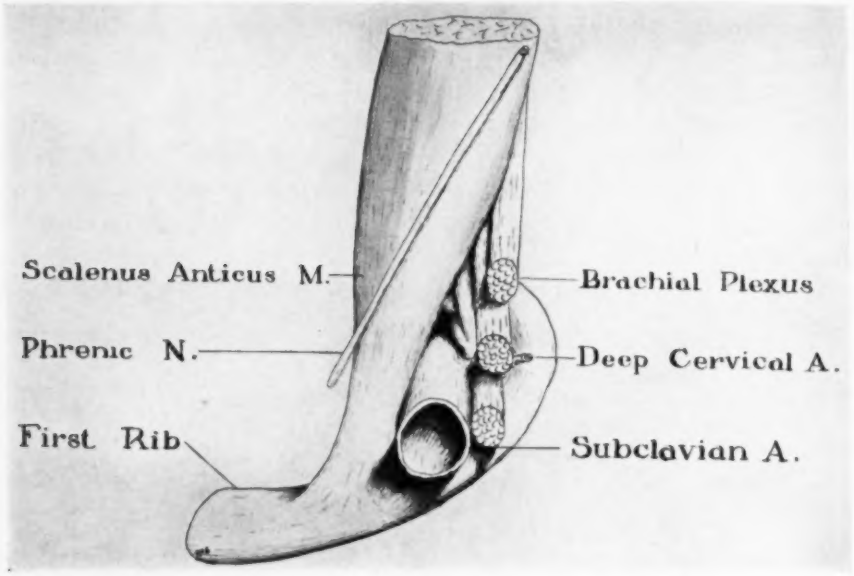

FIG. 4.

At the level of the eighth cervical nerve one encounters the first rib, although in one case a cervical rib was encountered between the seventh and

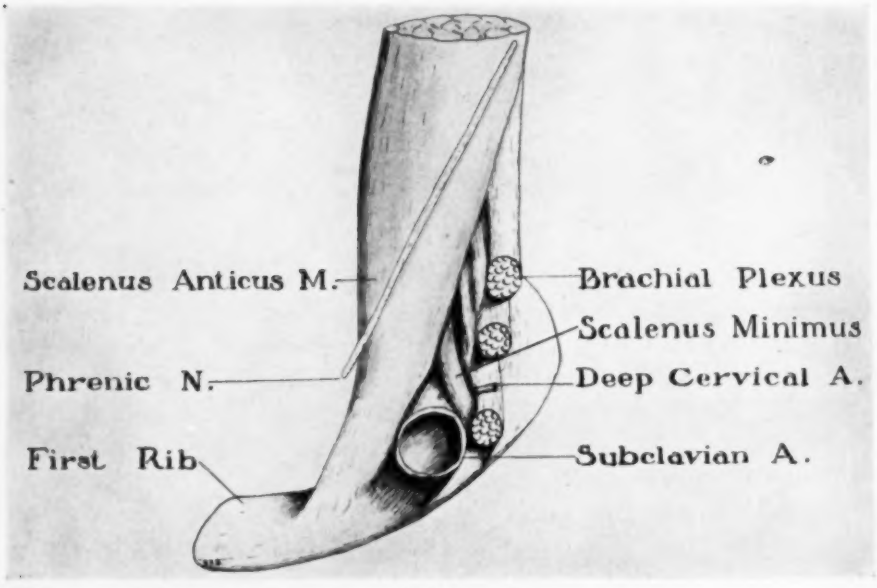

FIG. 5.

eighth nerves and had to be rongeured away. (Fig. 4.) Over the first rib, or the cervical rib, lies the subclavian artery. (Fig. 5.) In about one-half

of the patients one finds a tendinous slip passing between the subclavian artery and the brachial plexus, this apparently is a division of the tendon of the scalenus anticus, but is described by Spalteholz as the scalenus minimus which inserts into the pleural dome and the first rib. It is always necessary to divide this tendinous slip for an adequate exposure. Closing the thorax above, the parietal pleura is reinforced by Sibson's fascia. The latter structure may be quite delicate, or it may be made up of very dense fibres. It is necessary to divide this fascia by either a blunt hook or dissector, being careful not to penetrate the parietal pleura. The parietal pleura is gently pushed from the ribs, working in a posteromedial direction. The first dorsal nerve can easily be found at this stage of the dissection winding its way from within the thoracic cavity around the first rib to join the under surface of the eighth cervical nerve.

One frequently encounters a swishing sound when working in this neigh-

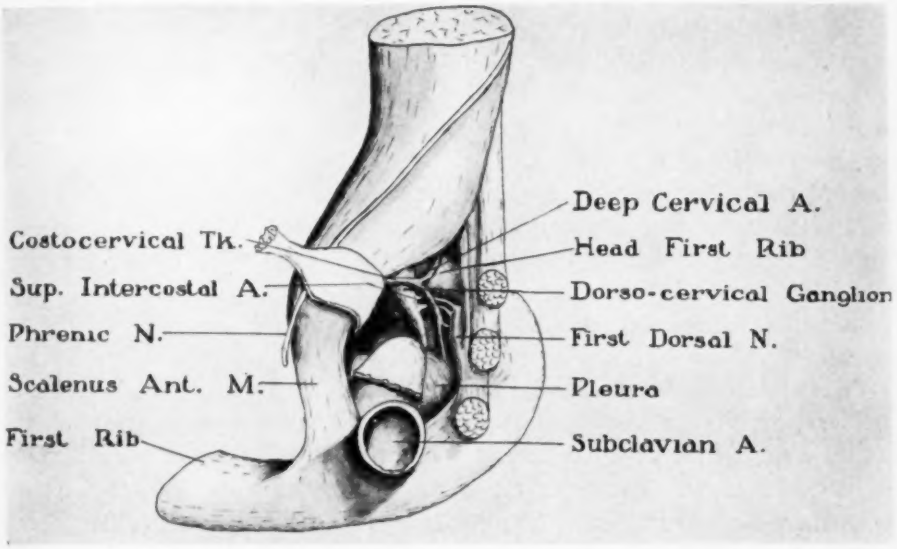

FIG. 6.

borhood, which is coincident with respiration, and one may see a hole, when the tissues balloon out, from which the sound apparently issues. This may occur without pleural puncture and may result in a cervical and facial emphysema.

Henceforward difficulties are immanent. While the sympathetic trunk lies at the costovertebral junction, another important structure lies just laterally which might be mistaken for the sympathetic trunk, *viz.*, the superior intercostal artery which supplies the upper intercostal spaces. (Fig. 6.) This artery passes backward over the medial surface of the pleural dome and turns downward over the inner surface of the costal cage. Accompanying this artery may be found a sizeable vein. Both the sympathetic trunk and the superior intercostal artery lie anterior to the intercostal nerves and run in the long axis of the thorax.

By means of long slender dissectors and hooks, one can pick up this artery and the sympathetic trunk. A long slender flat spoon is most helpful in reflecting light into this dark corner. (Fig. 2B.) The artery has the usual arterial appearance, but its small intercostal branches may simulate the rami. The sympathetic trunk lying just medial to this artery is usually white and taut, but it may be darkened and resemble a vein. One can assure himself by following the trunk upward and downward exposing ganglia and rami; or by inserting a hypodermic needle into the structure and watching for the appearance of blood. All the tests being negative, one divides the trunk with some reassurance, although with trepidation.

The sympathetic trunk at the dorsocervical junction may be of two main structural types: (1) The most common in our experience is a massive elongated ganglion which combines the first dorsal, inferior cervical, and possibly the second dorsal. (2) Less frequently the various ganglia are discrete. According to Kuntz[4] rami from the second dorsal ganglion may pass upward to the first dorsal nerve.

The ganglionic trunk having been found, one holds it up on a small hook, and with a second hook determines the presence of branches and of the trunk superior to this ganglia, the trunk is very taut and it is necessary to exert considerable force in this attempt. The branches are divided and the trunk severed above the lower cervical ganglion and again below the first dorsal. Any branches coming from the second cervical ganglion to the first dorsal trunk are also divided. The tissue so loosened is removed from the operative field for pathological examination.

Suturing of the sternocleidomastoid and superficial tissues completes the operation.

The anterior approach carries with it little shock (we have had no deaths in ninety-nine operations) and patients frequently leave the hospital on the second day. Horner's syndrome is usually observed following trunkotomy or ganglionectomy. The drooping of the eyelid gradually disappears except when the patient is fatigued. The clearing process may go on for two years.

The operation is easier in children than in adults, and the operative time varies from forty minutes in childhood to as much as two and one-half hours in a short-necked adult. One thing more than any other facilitating either operation is adequate lighting. We have used all varieties of lights, but the only one that is satisfactory is the Scialytic spot light. It is best to shut out cross lights, which are extremely confusing.

We feel that the technic of operations on the sympathetic nervous system is well established. We feel on the other hand that we are but standing on the borderland of possibilities so far as the indications for operation are concerned.

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THE SURGICAL ASPECTS OF THE AUTONOMIC NERVOUS SYSTEM

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It is the purpose of this paper to present the surgical aspects of the autonomic nervous system from a clinical viewpoint.

Historical.—Jonesco,[29, 30] 1896, divided the trunk above and below the middle cervical sympathetic ganglion for epilepsy, and a year later he repeated this operation for exopthalmic goitre. Then, in 1899, Alexander[7] removed both superior cervical sympathetic ganglia for epilepsy. However, little of note was accomplished until Jaboulay,[28] 1899, and Higier,[25] 1901, recommended tearing the nerve plexus around the femoral artery in cases of intermittent claudication. Leriche,[39, 40] who established periarterial sympathectomy, reported two cases of causalgia in which benefit was obtained by resection of the sheath of the brachial artery in 1917. Since that time Leriche[39, 40] has reported a large series of cases in which resection of the sheath of the artery relieved the vasoconstriction in such cases as Raynaud's disease, causalgia, trophic ulcers and the superinduced spasm of the collateral vessels in thrombo-angiitis obliterans.

However, the observations of Kramer and Todd[33] and Potts[42] and Kuntz[35] demonstrated that the operation of periarterial sympathectomy was anatomically unsound because the sympathetic innervation of the peripheral vessels corresponds to the segmental musculocutaneous distribution of the spinal nerves.

In 1924, Hunter[27] and Royle,[47] endeavoring to relieve spastic paraplegia by ramisection, noted a post-operative increase in the temperature of the extremities, and a short time later Adson[3] and Brown[9, 10, 11] reported the first cases of Raynaud's disease in which lumbar sympathetic ganglionectomy and ramisection was performed with gratifying results. Subsequent observation of these cases for the past eight years demonstrates that the lower extremities have remained warm, dry and pink. Adson[4] prefers the anterior approach in order to sever all the inconstant rami in front of the vertebral column which might be missed by the posterior route.

The anterior approach to the inferior cervical and first thoracic sympathetic ganglia met with failure more often than success, and until the posterior approach was devised by Henry,[24] 1924, and Adson,[5] 1928, little was accomplished in the treatment of peripheral vascular diseases of the upper extremities. Since that time, many important contributions have clearly indicated the therapeutic value of sympathetic ganglionectomy in carefully selected cases of peripheral vascular disease.

In addition to the brilliant results achieved in vascular conditions, an

equally important chapter has been written in efforts directed toward relief of intractable pain. During the past decade, the contributions of Swetlow,[53] White[56, 57] and Mixter[41] in reference to relief of the pain of angina pectoris have been outstanding. These procedures consist of either alcoholic injection or removal of the sympathetic ganglia. Also, the work of Archibald[8] and Scrimger[50] and Verbrugge[13] and von Bogaert[13] in alleviating abdominal pain and Stern's[52] success in relieving the distress of thrombo-angiitis obliterans have been of value. In 1927, Rowntree[46] and Adson, and Henderson[23] and Adson,[46] 1932, described a series of cases of arthritis in which benefit was obtained by sympathetic ganglionectomy. Flothow,[17, 18] 1931, and Abbott,[1, 2] 1932, reported cases of intractable pain in various regions of the body which were relieved by alcoholic injection of the sympathetic ganglia.

PERIPHERAL VASCULAR DISEASE.—**(A) Vasospastic Conditions.**—*Raynaud's Disease.*—This is the most classical vasospastic condition to be seen in any type of vascular lesion. The disease is characterized by bilateral vasoconstriction of the hands and feet. Little has been added to Raynaud's[45] original description when he observed a form of gangrene of the extremities without any evidence of vascular occlusion.

This phenomenon is seen chiefly in women. Few cases of pure vasoconstriction are observed in men without some evidence of vascular occlusion. The symptoms vary in degree to such an extent that many cases of mild vasoconstriction are erroneously diagnosed as a true Raynaud's disease. These patients present a coldness of the hands and feet, some blanching of one or more digits and a moderate amount of pain when exposed to the cold weather. Relief may be obtained by the application of heat and warmer clothes so that a surgical procedure is unwarranted. However, a true Raynaud's disease is characterized by the presence of symmetric color changes in the extremities varying from blanching to a deep cyanosis, clammy and cold extremities. There is intense pain from the vasospasm which is provoked by exposure to the cold or emotional influences. The gangrene of Raynaud's disease begins as a small trophic ulcer at the tip of the finger or toe and is associated with a distortion of the growth of the nails.

Sympathetic ganglionectomy and ramisection will provide maximum dilatation of the vessels and immediately after operation the extremities are warm, dry, pink and free from pain. The removal of the inferior cervical and upper two dorsal sympathetic ganglia for relief of vasospasm in the upper extremity is attended with a Horner's syndrome, but when the operation is performed on both sides, this sequela is hardly noticeable. This syndrome consists of a narrowing of the palpebral fissure, a constriction of the pupil, and absence of perspiration over the face. There is also a dilatation of the retinal veins and increase in the calibre of the arteries of the nasal mucosa followed by an increased secretion. This slight discomfort seems negligible in comparison to the severe pain in the extremities and danger of gangrene. It is obvious that all cases of vasoconstriction should be carefully

selected for surgery so that there will be full assurance of obtaining a maximum blood supply by removing the sympathetic ganglia.

Causalgia is a painful condition following trauma to the peripheral nerves, chiefly the ulnar, median and sciatic nerves. There is a complaint of constant pain, and the skin is glossy, red or mottled red and white. Joint and muscle action seems limited, apparently because of the intense pain. A number of cases have been reported in which sympathetic ganglionectomy or alcoholic injection of the ganglia have afforded relief; however, this type of case must be selected with utmost care because of the psychic and compensation element.

Scleroderma is a disease of the skin characterized by pigmentation, thickening or atrophy, and is frequently associated with sclerodactylia. Although there are several forms of this disease, the one group giving a previous history of cold, clammy, cyanotic extremities is amenable to surgical intervention. Sympathetic ganglionectomy increases the blood supply to the affected extremity, and there is a subsequent loosening of tight skin.

Arthritis.—In treating arthritis, an attempt is made to obtain maximum blood supply to the joint involved. In a small group of cases, a history of cold, clammy, cyanotic extremities is significant and, provided temporary vasodilatation produces relief, the removal of the sympathetic ganglia is of distinct benefit. However, there is no group of cases in which deliberate judgment is required any more than in the arthritic patients, who are possible candidates for surgical intervention.

(B) Vaso-occlusive Conditions.—*Thrombo-angiitis obliterans* is a disease of the blood-vessels characterized by arterial occlusion, varying degrees of color changes in the extremities, pain and extensive gangrene. Buerger's original description stated that this condition occurred only in Hebrews, and that cigarette smoking was a definite contributing factor. However, subsequent observations have demonstrated that no race is immune and, although immoderate use of tobacco will produce a vasoconstriction, this condition is seen also in non-smokers. There is a predominance in the male sex, but recently a number of cases of women have been reported. The course of this disease is slow, and for some time may be manifested only by coldness and cyanosis of the extremities. A little later there is definite blanching of the digits upon exposure to the cold, and if the occlusion is present in the lower extremities, there will be intermittent claudication on walking. Following these symptoms, color changes appear, varying from a deep rubor to a marked cyanosis which is replaced by blanching when the extremity is elevated. Gangrene appears in two ways, either as a trophic ulcer which rapidly assumes serious proportions, or around the base of the nail and involves all or part of one digit. Examination reveals diminution or absence of pulsations in the arteries of the extremities, and unless adequate collateral circulation can be obtained, amputation is imminent.

It is obvious that nothing can be accomplished with the occluded vessel, but the superinduced spasm of the collateral vessels can be relieved by sever-

ing the vasoconstrictor fibres, so that by dilatation of these vessels an increase of blood volume will be produced and relief of pain will be achieved. Often, it is preferable to administer hypertonic saline intravenously before resorting to surgery, because through the principle of osmosis an increase in blood volume is attained. It is to this end that removal of the sympathetic ganglia is directed, but the utmost care must be exerted in the selection of cases for this procedure is a major operation and there must be sufficient assurance that sympathectomy will produce an adequate increase in blood supply.

Arterial sclerosis is an unwelcome companion of senescence, and although there is little chance of dilating brittle arteries, relief from intractable pain and provision for maximum blood supply can be obtained. In these patients, alcoholic injection of the sympathetic ganglia is the procedure of choice for it carries practically no risk in skilled hands and the relief from pain is preferable to massive doses of narcotics. It is not infrequent that there still remains an element of vasoconstriction and it is gratifying to see an ulcer heal or an amputation at a lower level following alcohol block.

Selection of Cases.—The success of sympathetic ganglionectomy in the treatment of peripheral vascular conditions is dependent upon the careful selection of cases and the thorough interruption of all of the vasoconstrictor fibres. There are four methods of determining the degree of vasospasm and to what extent an increase in blood supply can be anticipated after ganglionectomy. These tests remove all elements of chance and are founded upon sound physiological principles.

(1) The "fever" test was devised by Adson and Brown,[6] 1925, and consists of the administration of typhoid vaccine intravenously and estimating the degree of rise in the surface temperature of the extremities in contrast to the rise in mouth temperature. This is an accurate test of relative blood flow to an extremity, and with the sympathetic fibres temporarily paralyzed, an accurate estimation of the vasoconstrictor element is obtained. It is necessary to use an electrothermocouple in these tests, and when a sufficient rise in surface temperature is manifested, it is an indication that sympathetic ganglionectomy will be of value.

The objection to the fever test is that it produces a severe generalized reaction and gives no information relative to pain relief.

(2) Spinal anæsthesia will produce vasodilatation, but this method is satisfactory for only the lower extremities and is impractical because it gives no information relative to relief of pain.

(3) Direct injection of the nerve trunks is of value because estimation as to pain relief is obtained in addition to the degree of rise in surface temperature. Scott[51] and Morton[51] have established this simple test and by this procedure can gauge accurately the amount of arterial spasm. The only danger in this method is in the doubt of interrupting all of the vasoconstrictor fibres to a given point.

(4) Direct injection of the sympathetic ganglia, as advocated by

White,[56, 57] produces a selective and discriminative result as both vasodilatation and pain relief are obtained in as large or limited an area as desired.

RELIEF OF PAIN.—*Pain of the head and neck.*—The reports of Mixter[41] and White[41] indicate that some of the pain fibres from the head and neck pass through the inferior cervical and first thoracic sympathetic ganglia before entering the spinal cord. This view is supported by Flothow's[17, 18] case, in which removal of the inferior cervical and first thoracic sympathetic ganglia provided relief from severe facial neuralgia after section of the posterior sensory root had failed, and Abbott's case in which alcoholic injection produced a similar result. However, Frazier's[21] results were unsatisfactory, but if the posterior approach had been used, the pain fibres might have been interrupted more completely. Recently, Dandy[15] has removed the inferior cervical and first two thoracic sympathetic ganglia in two cases of hemicrania with satisfactory results over a period of many months. It is unquestionable but that pain of the head and neck can be relieved by obliteration of the inferior cervical and upper two thoracic sympathetic ganglia when other methods have failed.

Thoracic Pain.—The most common type of pain in the chest is angina pectoris, and yet it is generally agreed that there are a number of types of this pain. In 1899, Franck[20] suggested that pain fibres from the heart traversed the thoracic sympathetic ganglia, and thirty years later, his contention was corroborated by Ranson[44] and Kuntz.[35] Although it is obvious that any surgical procedure in angina pectoris is only palliative, relief of pain is often a paramount factor in the course of the disease. Numerous operations have been proposed from removal of the superior cervical sympathetic ganglion down to and including the fifth thoracic ganglion. Such major procedures upon a patient with a poorly functioning cardiac mechanism seem unwarranted when the afferent visceral fibres can be so easily interrupted by injection. This was first demonstrated by Brunn[12] and Mandl,[12] 1924, who utilized paravertebral block with procain, and Swetlow,[53] 1926, who added alcohol in the injections. Since then, a number of gratifying reports have appeared in the literature, and, at present, the technic of White[56, 57] seems most satisfactory. This consists of injection of the upper five thoracic sympathetic ganglia with 85 per cent. alcohol. Stress must be laid upon the careful selection of cases, for it is only in the cases where there seems to be evidence of vasospasm that this procedure is indicated.

In addition, other types of thoracic pain, such as thoracic crisis, have been relieved by either ramisection or ganglionectomy.

Abdominal Pain.—Every surgeon is at some time or other confronted with the problem of the patient with severe abdominal pain which has failed to respond to the usual series of operations upon the stomach, gall-bladder, appendix and pelvic organs. No doubt but there are certain types of neurogenical pain which can be relieved only by interruption of the visceral afferent fibres. This can be accomplished by either ganglionectomy or injection as

indicated in the reports of Archibald,[8] Scrimger,[50] von Bogaert and Verbrugge,[13] von Gaza,[22] Woodbridge[58] and Abbott.[1, 2]

It is now definitely established that lumbar sympathetic ganglionectomy will relieve the dilatation of the colon in Hirschsprung's disease following the work of Wade and Royle,[55] Adson and Judd,[31] and Learmonth[36] and Rankin.[43]

The contributions of Leriche,[38] Havelaque,[26] Fontaine and Herman[19] have been of definite value in providing comfort to patients suffering from intractable pain in the pelvis of unknown origin. In addition, the work of Learmonth,[37] in alleviating the distress of cord bladder and certain bladder conditions by removal of the hypogastric plexus has been an epoch-making achievement. However, as in all cases under consideration for sympathetic ganglionectomy, extreme care must be exerted in the selection of each individual case.

Spastic Paralysis.—Sympathetic ganglionectomy and ramisection in spastic paralysis is directed toward release of the plastic component of the tonus of skeletal muscles and was advocated by Royle[48, 49] and Hunter. This procedure was not proposed as a cure for spastic paralysis, but, according to Royle, "it merely removes a factor which has been interfering with the normal physical education of the individual, and the essential treatment of spastic paralysis is education of the central nervous system."

Royle has achieved some definite benefit by ganglionectomy as also have Carrell[14] and von Lackum.[54] However, Kanavel,[32] Pollack[32] and Davis[16] found this operation to be of no appreciable value in spastic paralysis from a number of causes.

More recently, Royle advocates thoracic ganglionectomy in lieu of removing the lumbar ganglia, and states as his reason that a vasodilatation of one-half of the cerebrum is achieved which reduces tone in the contralateral extremities. Thus it seems that no definite opinion can be voiced at present as the reports are too conflicting to speak finally without further research.

Surgical Procedures.—*Periarterial sympathectomy* consists of removing the adventitia of the artery over a distance of two or three inches. This operative procedure is mentioned only to be condemned as anatomically and physiologically unsound.

Cervico-thoracic sympathetic ganglionectomy is performed by making a mid-line incision from the tip of the spinous process of the fifth cervical vertebra to the fourth dorsal vertebra. Then the tendinous attachments of the trapezius, rhomboid and posterior searatus muscles are severed and these muscles are retracted laterally. This leaves the erector spinæ and lower end of the splenius capitis muscles exposed and a blunt dissection will remove the periosteum over the first thoracic vertebra and rib for a distance of three centimetres. After resecting this area of the rib, with the transverse process of the first thoracic vertebra, the lung and pleura are retracted laterally and the sympathetic trunk is exposed. The inferior cervical, first and second thoracic sympathetic ganglia with their rami are then removed.

Lumbar sympathetic ganglionectomy is accomplished by making a midline abdominal incision, packing the intestines away and incising the posterior peritoneum from the promontory of the sacrum up over the aorta for a distance of fifteen centimetres. The psoas muscle is retracted laterally and the lumbar sympathetic ganglia with their rami are removed from the second to fourth, inclusive, on both sides.

Alcoholic injection of the sympathetic ganglia is performed by placing the patient in the prone position and inserting needles 2.5 centimetres lateral to the spinous process of the vertebra corresponding to the ganglion to be injected. The needle is directed down until the transverse process of the vertebra is felt and then inserted 2.5 centimetres below this point. Five cubic centimetres of 1 per cent. procain are injected, followed by four cubic centimetres of 95 per cent. alcohol. It is not uncommon for neuritic pains to follow an injection of this type, but these are controlled by salicylates and disappear in two or three weeks.

SUMMARY.—The surgical aspects of the autonomic nervous system are founded upon the physiological principles of local asphyxia or conduction of afferent visceral pain impulses. A review of the various conditions is presented in the hopes that it will stimulate further research into a relatively unexplored field and perhaps solve many perplexing problems. It is essential, however, to stress the careful selection of cases so that the brilliant results of the past will not be thrown into disrepute by attempts to combat disease by procedures not based on sound fundamental principles.

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INTERMITTENT CLAUDICATION WITHOUT GANGRENE CONTROLLED BY SYMPATHETIC NERVE BLOCK

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Amelioration of the distressing and frequently incapacitating intermittent claudication that appears in the arteriosclerotic individual may be effected by interruption of the sympathetic control of the arteries to the involved extremities. The degree of relief varies greatly, but may be accurately determined by diagnostic interruption of the lumbar sympathetic chain with novocaine. Other tests such as typhoid vaccine, spinal anæsthesia or peripheral nerve block which are excellent for determining the thermal response are quite unsatisfactory in measuring relief of pain. Furthermore, relief from pain may often be secured by sympathetic interruption even in the absence of an appreciable rise in dermal temperature.

Flothow's report[1] in 1931 on the sympathetic alcoholic injection for the relief of arteriosclerotic pain and gangrene at once stimulated a renewed effort to bring some relief to these unfortunates who reappeared in the clinic at intervals but who previously had received little if any help. For several years relief of pain in Raynaud's disease, thrombo-angiitis obliterans, scleroderma and certain cases of arthritis with obvious vasomotor instability has been effected in the Stanford clinic by interruption of the sympathetic pathways. Following Flothow's paper the procedure has also been applied in over twenty-five elderly people suffering with claudication. As a measure of its success it may be said that they are a group of most grateful patients.

Present knowledge indicates that sympathetic nerves to an extremity accompany and are a part of the peripheral nerves. They emerge from the nerve trunks at intervals to innervate segmentally the walls of arteries and veins, sweat glands and hair follicles. Beside these efferent fibres there are certain afferent sympathetic nerves that convey pain and other sensations.

Interruption of the sympathetic nerves to an extremity produces certain obvious changes due to the release of the vasoconstrictor impulses.[2] The skin becomes warm and dry and the superficial veins are visibly dilated. Experimentally, if a hemisympathectomy is performed, arterial injection through the heart six weeks later with Hill's bismuth oxychloride mass, which visualizes the arterial system in röntgenograms, reveals not only a slight dilation of the main arteries of the sympathectomized side, but a definite enlargement of the arterioles as well, so that many more small vessels become visualized than on the control side. (Figs. 1 and 2.) In comparing the röntgenograms of injected amputated limbs from arteriosclerotics with those made when amputation was performed several weeks after a sympathetic block, the striking appearance of many small, minute arteries, especially in the region of the

foot and ankle, is in sharp contrast to their absence in the non-sympathectomized arteriosclerotic amputated extremity.

Earlier diagnostic measures employed to determine the degree of dys-

FIG. 1.

FIG. 2.

FIG. 1.—Hill's bismuth oxychloride mass injected through the heart into the arterial system of a dog six weeks after left hemisympathectomy. There is slight dilatation of the main vessels and many more visual and enlarged arterioles on the sympathectomized side. Upper half of body.

FIG. 2.—Lower half of body of dog injected with Hill's arterial mass six weeks after left hemisympathectomy. The slight enlargement of the main arterial trunks and the dilatation of the arterioles are especially evident in the left extremity.

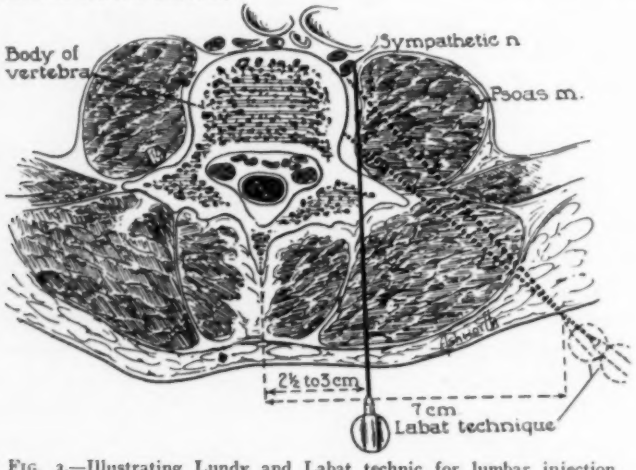

FIG. 3.—Illustrating Lundy and Labat technic for lumbar injection. (From Flothow, Amer. Jour. Surg., Dec., 1931.)

function of this nervous system in the limb were mainly dependent upon the thermal changes induced by foreign protein, hot baths or spinal anæsthesia. Since it is the relief of pain for which these patients seek help, a test that

would indicate the degree of relief from pain obviously would be more satisfactory, particularly in the arteriosclerotic group where the thermal skin response may be insufficient to warrant any sympathetic interruption. The most satisfactory test for measuring alterations in pain (as well as securing the measurement of the thermal response in the skin), and one which will in a large measure permit the patient to be the judge, is the interruption of the autonomic impulses alone by the paravertebral novocaine injection of the sympathetic chain and ganglia as advocated by White.[3] This injection does not interfere with any activity of the patient and when applied while the patient has pain or can induce pain serves as an exact criterion of the relief than can be secured either by operative removal or alcoholic injection of that portion of the sympathetic nervous system.

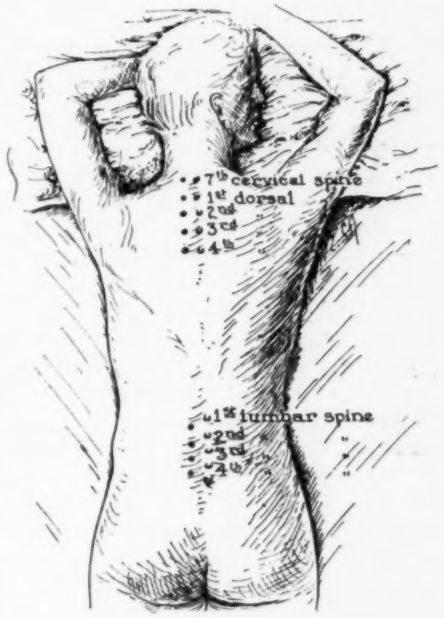

FIG. 4.—Point of insertion of needles for dorsal and lumbar injections using Lundy technic. First dorsal segment lying opposite the seventh cervical spine, showing that dorsal injection is made opposite spine and lumbar injection opposite interspaces. (Reproduced by permission from the Amer. Jour. Surgery, Dec., 1931.)

When the release of sympathetic impulses in a limb by novocaine has demonstrated a favorable influence on the symptom of pain the interruption in elderly people can be made permanent by the alcoholic injection of the sympathetic chain. In the majority of cases within two or three weeks after the injection of alcohol the increase in distance traversed before the onset of claudication has been double or triple that determined by the diagnostic test. The injection is performed in the same manner as for the diagnostic novocaine block and can be done in the ambulatory patient without any general anæsthesia. The greatest difficulty with the injection method is the accurate placing of the ends of the needles in approximation to the sympathetic chain. Using the method of Labat or the more recent modification of Lundy and described by Flothow,[4] when the ends of the needles are close to the sympathetic chain the unanæsthetized patient, during the introduction of the first cubic centimetre of alcohol will complain of transient epigastric or abdominal pain. Failure to secure this upper abdominal pain is indicative that the needle points are not near the sympathetics and that they must be shifted to a more accurate position. The illustrations (Figs. 3 and 4) from Flothow's paper visualized the course of the needles. For the lower extremity three needles placed opposite the interspaces at lumbar 1, 2 and 3 are usually sufficient.

Theoretically, if the ganglia are destroyed by alcohol, the result should be as permanent as operative removal. Some of our patients have been relieved for a period of two years after one injection. Others have been reinjected one or more times before the block has become effectual. The diffusion of alcohol always produces peripheral neuralgia but it is less severe and not incapacitating when the block is made for the lower extremities.

The following case report illustrates the method and its application. An American caretaker, sixty-nine years old, first entered the Stanford Clinic in 1928 when a large epithelioma of the lower lip and the regional lymph-glands was excised. Metastases to the mandible were successfully treated by deep Röntgen-ray therapy two years later. Anacidity without known cause led the clinicians to maintain a continued interest in him.

In February, 1932, cramps in his calf muscles developed and became so severe that he was unable to walk even a city block before he was forced to stop and rest. Contrast baths to the lower limbs and graded exercises produced no appreciable improvement. The left heel became painful and the feet were damp and cold. Bed socks helped but even at night cramps would develop and force him to walk about his room.

In the dependent position his feet were reddish purple and blanched quickly on elevation. No pulsation could be felt in either posterior tibial or dorsalis pedis arteries.

May 9, 1932, as a diagnostic procedure, the lumbar sympathetic chain on both sides was blocked with novocaine. Previous to the block he could walk only five turns in the corridor before claudication developed. Immediately after the block he doubled this distance before pain appeared so that he was quite emphatic that the "serum" warmed his feet and enabled him to walk farther.

The bilateral interruption of the lumbar sympathetic chain was made permanent by alcoholic injection May 11th. As the first cubic centimetre of alcohol was injected he complained for several minutes of precordial and epigastric pain.

When he reported to the clinic, May 17th, he was able to walk fifteen city blocks before the onset of claudication, the left heel was no longer painful, and the pulsations of the left dorsalis pedis artery were faintly felt. He complained of neuralgic pains in his back and groin.

He was admitted to the medical service June 13th complaining of palpitation and shortness of breath. Chronic myocarditis with moderate myocardial insufficiency was diagnosed. It was learned that the relief from claudication had led him during the three days before admission to take long walks in the park and on the beach. This excessive exercise apparently precipitated the cardiac disturbance.

When seen October 1st, nearly five months after injection, he reported that he had been working all day since June without any discomfort in his feet, and although he felt a slight aching in the calves after walking two or three blocks, he could traverse six to eight blocks before the cramps stopped him. Neither coldness of his feet nor cramps bothered him at night. Both feet were warm and dry with many visible dilated veins. The right dorsalis pedis artery was easily palpable but pulsations were not definitely felt in the left foot.

One of the two women treated in this group of twenty-five patients with intermittent claudication had a hemiplegia six years before. Her cold, aching limb became warm, free of pain and permitted an increase in the distance walked to three or four blocks before the onset of cramps. The relief from cramps at night which had interfered with sleep is always commented upon by these patients. An increase of distance from one-quarter or one-half a city block to two, four or even ten blocks is a great asset to these people and frequently enables them to secure work. Several patients who have been

previously helped by contrast baths and graded exercises obtained further improvement after sympathetic block. Since the dominant factor in the condition of these patients is circulatory, protection of the limb from cold must be continued even after sympathetic block.

Claudication is a symptom of a generalized pathological process. Relief of the local manifestations in the extremities can be given by sympathetic block. In time even the improvement from vasodilatation and the relief from pain are frequently not sufficient to prevent the advances of the pathological process and only amputation remains. Yet years of comfort and amelioration of the cramps in the lower limbs may be offered to some of the arteriosclerotic individuals by regional sympathetic nerve block.

SUMMARY

Relief of intermittent claudication in the arteriosclerotic individual may be secured by interruption of the sympathetic pathways with alcohol.

The usual tests to determine the efficiency of sympathetic interruption such as the thermal response in the skin to spinal anæsthesia, foreign protein or peripheral nerve block are not applicable in determining the effect of such interruption on the pain of claudication. Relief of pain is not infrequently obtainable even in the absence of a rise in skin temperature. When the thermal response alone is the only criterion for or against sympathetic interruption, certain cases will be overlooked in whom sympathetic block will be of distinct benefit.

A satisfactory diagnostic procedure to determine the relief from pain is a paravertebral injection of the sympathetic chain with novocaine which enables the ambulatory patient to assist the physician in judging whether permanent interruption will be beneficial.

Twenty-five cases of intermittent claudication without gangrene have been materially and occasionally strikingly benefited by permanent interruption of the sympathetic chain by paravertebral injection of alcohol following the diagnostic use of novocaine.

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PHRENIC NEURECTOMY

RESULTS IN 100 CASES

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Phrenic neurectomy, or more briefly phrenicectomy, has been resorted to by phthisiologists with increasing frequency during recent years. The precise value and status of this operation in the group of intervention procedures used in pulmonary tuberculosis have not yet been determined. It may be used as an adjunct to therapeutic pneumothorax and to thoracoplasty, or it may be employed as an independent procedure.

The phrenic nerve is derived from the third, fourth and fifth cervical nerves, and runs downward, lying upon the anterior scalene muscle and crossing it diagonally from its lateral border. The nerve continues downward into the thorax, passing between the subclavian artery and vein. It is occasionally joined by accessory nerves, which rise from the fifth and sixth cervical nerves, and unite with the main nerve in the lower part of the neck or in the thorax. The interruption of these accessories is most surely accomplished by the evulsion of at least 10 centimetres of the phrenic nerve, and this fact has given phrenicectomy its place of major importance as the method of paralyzing the diaphragm. It is important to remember that anomalies of the phrenic nerve may be present. These have been described by Matson.[1]

At Loomis Sanatorium the operation is performed under local anæthesia after giving a preliminary hypodermic of morphine sulphate, gr. 1/6. The skin may be prepared with tincture of iodine or 5 per cent. alcoholic solution of picric acid. The patient lies on his back, without supporting pillows, and with his head turned away from the field of operation. The lateral border of the clavicular head of the sternomastoid muscle is located at a point 2 centimetres above the clavicle, and with this site as a mid-point the skin and subcutaneous tissues are infiltrated with 1 per cent. procaine parallel to the skin folds. In this line an incision 3 to 4 centimetres in length is carried through the skin, fascia and platysma, exposing the lateral border of the sternomastoid muscle. By blunt dissection the sternomastoid is freed and drawn mesially. At this point the anterior scalene muscle, which is recognized by its rounded contour, is located by palpation. The blunt dissection is then directed toward exposing the anterior scalene. The nerve is typically located under the fascial plane overlying the anterior scalene, but may be found along the lateral or medial border of the muscle. It is identified by gentle pinching which will cause a contraction of the diaphragm and pain which is usually referred to the anterior surface of the shoulder. The nerve is then grasped with a hemostat or with a phrenic evulsion forceps, and is cut and the lower end slowly withdrawn from the chest by winding upon the forceps. The fibres

of the nerve may rupture, or the entire nerve may be evulsed; one evulsed nerve in this series measured 40 centimetres in length. If undue tension is present and the requisite 10 centimetres has been freed, the nerve is cut to avoid injuring intrathoracic structures. Hemostasis is then cared for, the platysma approximated by two or three interrupted sutures of plain 00 catgut, and the skin closed without drainage by a subcuticular stitch. The actual evulsion is unavoidably attended by pain which may be very severe. Postoperative discomfort, however, is not marked. The operative technic has been described by Alexander,[2] Matson,[1] and others.

Crushing of the nerve may be done instead of evulsion. After identification the nerve is infiltrated with procaine. The lateral border of the anterior scalene muscle is then exposed as far downward as possible and any accessory trunks which are located are cut. The phrenic nerve is now crushed at one point by a Kelly hemostat. This procedure is almost entirely painless. The temporary paralysis of the diaphragm which results is of approximately six months' duration. Re-operation, if required, is not very difficult.

During the past four years the staff of Loomis Sanatorium has endeavored to apply and to evaluate phrenicectomy. A number of patients enter the sanatorium with extensive lesions or an obviously acute clinical course. It is the practice of the staff to institute therapeutic pneumothorax at once for all in this group if possible. Other patients show lesions whose estimated potentialities for healing are such as to warrant a period of bed rest and observation before a decision is made to use collapse therapy. The choice then lies between therapeutic pneumothorax and phrenicectomy, and may, if the pleura is adherent, necessarily be phrenicectomy. The operation has been advised after careful consideration of each case. In each patient the position of the diaphragm on inspiration and on expiration was recorded by X-ray films immediately before operation, two weeks after operation, and every thirty to sixty days thereafter. The patient's vital capacity was determined before and after paralysis of the diaphragm. The X-ray interpretations regarding presence or absence of cavity, thickness of cavity wall, position of cavity and type of surrounding infiltration were all made by the staff röntgenologist and may be regarded as uniform. The sputum was considered negative only when microscopical examination of smears of the concentrated sputum failed to reveal tubercle bacilli.* For purposes of formal classification the Standards of the National Tuberculosis Association have been used.

The success of any collapse procedure can be stated clearly only when the result to be attained has been defined. Technically a phrenicectomy is successful if the diaphragm is paralyzed. Superficially it may be regarded as benefiting the patient if there is a decrease in the size of the cavity and a

* The method employed by Dr. J. Stanley Woolley, Director of the Babbitt Memorial Laboratory, is as follows: Up to 1 ounce of sputum is treated with one volume of 1 per cent. NaOH, shaken and incubated over night. One volume of 0.4 per cent. H_2SO_4 (by volume) is then added and the mixture centrifuged. The sediment is stained for tubercle bacilli with Cooper's stain.

diminution in the amount of sputum. The Loomis staff, however, considers the procedure successful only when the X-ray film no longer reveals a cavity and the sputum is consistently negative for at least three successive months. In other words, only those patients discharged as arrested or apparently arrested are regarded as showing a successful result following this procedure.

The staff has withheld phrenicectomy in patients whose lesions might be expected to heal promptly on bed rest alone. The sacrifice of diaphragmatic function in cases with unilateral disease when bed rest may effect an early cure would seem to be unjustified. The paralyzed diaphragm may be a handicap in the future care of the patient, and there is as yet inadequate evidence as to the ultimate effect of the lost diaphragmatic function on respiration and circulation. Operation is also withheld if the lesion appears to be too extensive to be controlled by paralysis of the diaphragm. Widespread caseation, consolidation of a lobe, and large cavities replacing an entire lobe are regarded as contraindications, although exceptions may be made when it is impossible to induce pneumothorax to control hemoptysis. Extremely dense apical lesions are considered unfavorable. Phrenicectomy has been given in borderline cases where pneumothorax might otherwise have been administered. These cases are designated elective phrenicectomies. In such cases pneumothorax is given if the lung, after phrenicectomy, requires additional compression. The application of phrenicectomy, therefore, cannot be decided by adherence to any routine formula, but requires the judgment of clinicians experienced in tuberculosis.

Phrenicectomy, as a mechanical aid, supplements bed rest as a means of healing the lesions of pulmonary tuberculosis. The closure of cavities may be expedited by the operation, but the fundamental requirement of time for fibrous tissue development about the foci of disease cannot be ignored; therefore adequate post-operative sanatorium care is a requisite in all cases.

The mechanical effect of phrenicectomy is twofold. In the first place there is ascent of the paralyzed diaphragm with consequent relaxation of the lung parenchyma which permits elastic retraction of the diseased area. In this respect phrenicectomy has much the effect of a partial pneumothorax. The second effect is immobilization of the diaphragm which affords rest to the pulmonary tissues. The degree of rest afforded is not absolute since pulmonary ventilation is effected by a combination of diaphragmatic motion and excursion of the ribs The part played by relaxation and by immobilization in the healing of tuberculous lesions is not constant and neither ascent of the diaphragm nor degree of immobilization can be used in establishing the prognosis for cavity closure.

The results in the 100 cases are shown in Table I. Ninety-eight of the cases included in this report received phrenicectomy; in two cases the phrenic nerve was crushed and the accessory nerve divided. As the diaphragm was paralyzed in these two patients they are considered with the phrenicectomies for the purposes of this paper. The 100 operations were performed between January, 1929, and July, 1932; thus there has been a period of observation of

six months since the last operation. Ninety-two patients were operated upon at Loomis Sanatorium, eighty by the writer, twelve by other surgeons, while in the remaining eight the operation antedated admission.

Of the seventy-five cases in the pneumothorax failure and elective phrenicectomy groups, sixty had definite round or oval cavities; the remainder had honeycombed excavations. In twenty of the sixty cavities a fluid level was demonstrated by X-rays. All had tubercle bacilli in the sputum.

Of the eight patients receiving phrenicectomy before admission two were discharged as quiescent; of these, one has since had a thoracoplasty and is doing well, the other is running a chronic course. Two were discharged as

TABLE I

Results in 100 *Phrenicectomies*

PHRENICECTOMY	Cases	Male	Female	Right	Left	Classification on Discharge						
						A	A A	Q	I	U	D	
PNEUMOTHORAX FAILURES												
Moderately Advanced	1	1	-	1	-	-	1	-	-	-	-	
Far Advanced	23	16	7	15	8	3	2	6	10	2	-	
TOTAL	24	17	7	16	8	3	3	6	10	2	-	
ELECTIVE PHRENICECTOMY												Given Pneumo
Moderately Advanced	20	14	6	10	10	1	8	8	1	-	-	2
Far Advanced	18	12	6	9	9	5	1	4	1	1	-	6
TOTAL	38	26	12	19	19	6	9	12	2	1	-	8
OPERATION BEFORE ADMISSION	8	3	5	4	4	-	-	2	2	2	2	
PRIOR TO REEXPANSION	13	4	9	3	10	Complete = 9			Incomplete = 4			
RELAXATION OF ADHESIONS	2	-	2	1	1	Successful= 1			Unsuccessful=1			
PRIOR TO THORACOPLASTY	2	1	1	-	2							
OBSERVED UNDER 3 MONTHS												
Pneumothorax Failures	6	3	3	6	-							
Elective Phrenicectomy	7	4	3	4	3							
TOTAL	13	7	6	10	3							

improved; of these, one has had a thoracoplasty and is not doing well, the other has since received pneumothorax. Two were discharged as unimproved and have since died, and two patients died in the sanatorium. The admission of these patients to the sanatorium after phrenicectomy had been performed implies that their disease was progressive; consequently they comprise a group of cases having an unfavorable prognosis. Nevertheless, it is felt that these eight cases exemplify an injudicious application of phrenicectomy since in three patients the pulmonary excavation was extensive, the largest cavity measuring 8 by 14 centimetres; furthermore, in seven of the eight the infiltration about the cavities was dense and widespread. The average age of the group was thirty-seven years; the average cavity area was 21 square centimetres, and the surrounding infiltration was moderate to heavy. These findings are to be contrasted with those appearing in the first column of Table III.

Of the two patients receiving phrenicectomy as a preliminary to thoracoplasty, one died of spontaneous pneumothorax before thoracoplasty was performed, and the other refused thoracoplasty and continues under treatment. The staff does not routinely recommend phrenicectomy prior to thoracoplasty, believing that the operation contributes little to a satisfactory result, and that, on the contrary, it may even be detrimental since paralysis of the diaphragm may decrease the ability to expel secretions during the post-operative period.

Upon two patients who were receiving pneumothorax phrenicectomy was performed to relieve the tension of diaphragmatic adhesions. In one patient the desired result was not attained and a thoracoplasty was eventually performed. In the other patient pneumothorax had been maintained for three and a half months, but the cavity had remained patent despite three months of positive intrapleural pressures. Within three months after phrenicectomy the cavity had closed and the sputum had become negative on concentration.

Phrenicectomy was utilized in thirteen patients as a preliminary to reëxpansion of collapsed pneumothorax lung, since those patients whose lesions had

TABLE II

Results in 62 Cases of Phrenicectomy

Combining 24 Pneumothorax Failures and 38 Elective Phrenicectomies

Cases	Arrested Cases	%	App. Arrested Cases	%	Quiescent Cases	%	Improved Cases	%	Unimproved Cases	%	Given Pneumothorax Cases	%
62	9	14.5	12	19.4	18	29.0	12	19.4	3	4.8	8	12.9

been large before pneumothorax may run a greater risk of exacerbation when pneumothorax is terminated. The elevation of the paralyzed diaphragm following phrenicectomy decreases the volume of the pleural space; hence less pulmonary reëxpansion is required. Reëxpansion is incomplete, as yet, in four cases; of the nine with reëxpansion complete, seven are well and working, one has had disease develop in a new area in the previously collapsed lung, and one who never had a consistently negative sputum has suffered an exacerbation.

Thirteen patients could not be followed for over three months after phrenicectomy and therefore their present status cannot be included as a part of this report.

Sixty-two patients have been followed for over three months after operation. Of these, twenty-four had adherent pleura precluding pneumothorax and are reported in the "pneumothorax failure" group, and thirty-eight received "elective phrenicectomy." The results in the sixty-two cases are shown in Table II.

The sixty-two cases summarized in this table are presented in detail in Table III. The outstanding fact is that twenty-one of the sixty-two cases secured an arrest or apparent arrest. These patients had had an average

period of pre-operative sanatorium care at Loomis of 6.3 months with unsatisfactory progress and persistence of cavity.

The average age of those showing a favorable result was 25.9 years; those over thirty years of age did not do as well. The influence of sex was not marked, and there was no material difference in the response of left- or of right-sided lesions. The degree of elevation of the diaphragm and the amount of vital capacity lost do not appear to be significant factors.

TABLE III

Results in 62 Cases of Phrenicectomy

Combining 24 Pneumothorax Failures and 38 Elective Phrenicectomies

	Arrests and App. Arrests	Quiescent and Improved	Unimproved Given Pneumothorax	Unimproved
Cases	21	30	8	3
Per Cent	33.9	48.4	12.9	4.8
Age (Average)	25.9	30.5	27.1	39.0
Male	15	22	3	3
Female	6	8	5	0
Right	12	16	3	2
Left	9	14	5	1
Preadmission months of illness	21	22	24.2	13.3
Classification on Admission				
Minimal	-	-	-	-
Moderately Advanced	10	9	2	0
Far Advanced	11	21	6	3
Preoperative Sanatorium Months	6.3	6.4	6.3	5.3
Postoperative Sanatorium Months	10.5	6.9	3.9	4.4
Elevation of Diaphragm (in cm.)	3.6	3.8	3.0	2.0
Average percentage loss of Vital Capacity	9.5	10.9	11.3	7.0
Months to Closure of Cavity	5.1	-	-	-
Months to Negative Sputum	5.2	-	-	-
DATA REGARDING CAVITIES				
Surrounding Infiltration:				
Light	7	3	1	-
Moderate	13	12	6	2
Heavy	1	15	1	1
Cavity Wall:				
Thin	13	11	3	1
Moderate	12	18	7	1
Thick	1	8	-	2
Medial	2	1	1	1
Central	12	9	1	-
Peripheral	12	27	8	3
Mid-Chest	5	6	4	-
Upper-Chest	21	31	6	4

The prognosis was better in the moderately advanced cases. There were, however, eleven arrests or apparent arrests among forty-one far advanced cases, a percentage of 26.8. It is to be noted that those patients who remained under treatment the longest secured the best results. The 5.2 months required for cavity closure after phrenicectomy may be compared with the figure of 5.0 months for cavity closure in successful pneumothorax cases as reported by Herben and Franklin.*

* Positive Pressure Pneumothorax, Its Indications and Results. Address delivered to the Trudeau School of Tuberculosis, Saranac Lake, N. Y., May 26, 1932.

The cavity areas recorded in this table have been roughly computed by multiplying the longest by the shortest diameters of the cavity as measured on an X-ray film taken at a distance of four feet. Obviously this is not entirely accurate, but for purposes of comparing groups of cases the method is useful. The facts set forth in this portion of the table confirm the observations of McMahon and Kerper,* who found that the cavity which is most likely to heal is not over 3 by 3 centimetres has a thin to moderately thick wall, is surrounded by light to moderate infiltration, and is not situated peripherally where a portion of its wall is adherent and immobilized. There is no evidence to indicate that cavities in the upper lobe respond less favorably than those located elsewhere, provided other conditions are comparable.

In a number of patients a discrepancy was noted between the excursion of the diaphragm before operation and its elevation after paralysis, when it was expected that the two would be comparable. In these cases motion of the diaphragm persisted after the operation. This motion did not represent a failure to paralyze the diaphragm, but was passive in nature, due in part to the excursion of the costal margin which caused a flattening of the diaphragm on inspiration, and in part to the abdominal pressure exerted on forced expiration which caused elevation of the diaphragm. This "passive motion of the diaphragm" has not heretofore been mentioned in the literature. Phrenicectomy may not be followed by complete paralysis of the diaphragm since this muscle is innervated also by branches of the lower intercostal nerves (the seventh to the twelfth, according to Spalteholtz, the ninth to eleventh according to Cunningham). In one patient, following phrenicectomy, the diaphragm was observed to show a limited downward motion in the absence of marked costal excursion. In this instance the intercostal innervation of the diaphragm was believed responsible for the partial diaphragmatic function which persisted. In eleven instances the average pre-operative excursion of the diaphragm was 5.5 centimetres, the post-operative elevation of the diaphragm measured on inspiration was 3.0 centimetres, and the "passive motion" measured 2.8 centimetres. This point is of practical importance in that the use of an abdominal binder after operation in patients manifesting "passive motion" may serve to increase the elevation of the diaphragm and thus augment relaxation of lung. It is also evident that X-ray observation of the effect of phrenicectomy requires films taken on deep inspiration and after normal—not forced—expiration.

In this series there were no serious operative accidents and no deaths. There were two superficial wound infections; in one case trauma to the sympathetic nerve resulted in a Horner's syndrome which disappeared in two months; in one case the external jugular vein was cut and ligated, and the thrombus which appeared was promptly absorbed. Brief post-operative elevation of temperature occurred once. The symptoms of brachial neuritis of traumatic origin occurred in two cases with recovery within two weeks. In

* The Healing of Tuberculous Cavities: A Clinical Study. Address delivered to the Eastern Section of the American Sanatorium Association, Waltham, Mass., October 14, 1932. (To be published in the American Journal of Medical Sciences.)

two patients with marked elevation of the diaphragm pulmonary atelectasis occurred; in one the entire left lung was involved, in the other the right lower lobe. Both received pneumothorax. The possibility of this complication must be borne in mind as it materially alters the problem of treatment. While many patients noticed slight dyspnœa in the early post-operative period, a quick readjustment was usually made and this was not a troublesome symptom in any case. Complaints of abdominal gas were varied, and apparently were somewhat more frequent in the patients with left-sided diaphragmatic elevation and subsequent increase in the "stomach bubble."

SUMMARY

Phrenicectomy is indicated and is a valuable independent collapse procedure when operative intervention is required in the treatment of a limited group of patients with pulmonary tuberculosis who have not responded to routine sanatorium care. The clinician's aid is important in selecting the cases suitable for operation. This collapse procedure is regarded as successful only when it is followed by closure of cavity as shown by X-ray and by consistently negative sputum. The best post-operative results are found in cases with a thin-walled cavity not over 3 by 3 centimetres in diameter with little surrounding infiltration and located centrally in the lung parenchyma. On the other hand, phrenicectomy promises little and should not be used in those cases with dense infiltration, thick-walled cavities, or large cavities.

Sixty-two cases in which phrenicectomy was the only operative procedure affecting the course of pulmonary tuberculosis are analyzed in detail, showing 14.5 per cent. discharged arrested, with sputum negative on concentration for six months or more; 19.4 per cent. apparently arrested, with sputum negative on concentration for at least three months; 29.0 per cent. quiescent, with constitutional symptoms absent for at least two months, but without consistently negative sputum; 19.4 per cent. improved, with constitutional symptoms lessened; 4.8 per cent. unimproved, with essential symptoms unabated; and 12.9 per cent. in which it was necessary to give pneumothorax.

An original observation is recorded describing "passive motion of the diaphragm" following phrenicectomy; the motion is due to a combination of marked costal excursion, which will flatten the diaphragm on inspiration, and to a rise of the diaphragm caused by forced expiration.

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BRONCHOSCOPICAL OBSERVATIONS ON POST-OPERATIVE PULMONARY COMPLICATIONS*

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Five distinct types of post-operative pulmonary complications have been observed in our experience:

(1) *Post-operative atelectasis;* chiefly following abdominal operations; not primarily suppurative.

(2) *Post-tonsillectomic suppuration;* chiefly following tonsillectomy and other operations about the upper air passages; suppurative from the onset.

(3) *Foreign bodies inspirated* during operations about the upper air passages; not primarily suppurative.

(4) *Infarct* that may follow operation upon any region.

(5) *Pneumonitis,* usually called post-operative pneumonia.

This loose grouping of cases is for the purpose of study of certain contrasts; it is not claimed that every case of post-operative suppuration can necessarily be placed in one or other of the groups; additional groups could be cited.

In order to present certain contrasts, groups 4 and 5 will be omitted. This omission is necessary for other reasons, chief of which are that in the clinical work on which this paper is based it was impossible to determine that any case was due to infarct; and the term pneumonia is so loosely applied that the term "post-operative pneumonia" in the history means nothing definite.[8] It might have been an infarct but probably in most cases it was some form of bronchial obstruction with or without atelectasis, with or without drowned lung. A new era is dawning now that Röntgen-ray examination at the bedside and early objective examination with the bronchoscope are being used to assist in diagnosis.[2, 8]

In the following tabulation there are certain contrasts that we believe have an important bearing on the etiology, diagnosis, prophylaxis and treatment of post-operative pulmonary complications.

Post-operative Atelectasis.—In these cases, formerly mistaken for post-operative pneumonia, there is at the onset a thick, tenacious, obstructive secretion that at first contains grossly no pus and on microscopical examination only a few pus-cells and few if any pyogenic bacteria.[2] If not quickly terminated by restoration of ventilation and drainage with consequent re-establishment of the defensive powers of the lung the atelectasis is slowly succeeded

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POST-OPERATIVE PULMONARY COMPLICATIONS

Post-Tonsillectomic Suppuration	Post-Operative Atelectasis	Post-Operative Foreign Body
(1) Follows operations about the upper air passages, most often tonsillectomy.	(1) Follows abdominal operations.	(1) Follows inspiration of foreign body during operation.
(2) Onset sudden.	(2) Onset sudden.	(2) Onset gradual, even if obstructive atelectasis is produced by the foreign body.
(3) Primarily suppurative.	(3) Not primarily suppurative.	(3) Not primarily suppurative.
(4) Abscess forms early, namely, within a few days, and very rapidly.	(4) Abscess late, if at all.	(4) Abscess late, if at all; a year or more in cases of steel foreign body; three months or more in cases of tooth, and it was not in any case a cavity associated with fluid level but rather a condition of drowned lung.
(5) Abscess shows cavity and fluid level early.	(5) Drowned lung first suppurative feature, if any.	(5) Local suppurative bronchitis. If complete obstruction drowned lung may follow atelectasis.
(6) Expectoration of pus and blood at onset very foul, gangrenous.	(6) Expectoration at onset absent or scanty, rarely, if ever, purulent or bloody, or odorous.	(6) Expectoration at onset absent or scanty; if a tooth, mucopurulent in a few cases; if non-obstructive steel instrument, may be months or years.
(7) Breath very foul at onset.	(7) Foul breath not a feature.	(7) Foul breath not an early feature.

by suppuration first in the form of drowned lung, purulent bronchitis, later abscess, possibly bronchiectasis. If, on the other hand, early bronchoscopical drainage promptly restores ventilation and drainage, as it usually does (Figs. 1 and 2), there is no tendency to the formation of a localized purulent collection. We rarely, in these cases, see anything remotely resembling an abscess cavity with fluid level such as is regularly seen in suppurative complications following tonsillectomy and operations on the upper air passages. The pathological products in atelectasis are largely if not altogether endobronchial.

These clinical facts, now well established by bronchoscopical observations, clearly prove that post-operative atelectasis is not suppurative at the onset. Moreover, these observations indicate that primarily it is not even an infective process.

Pulmonary Suppuration Following Operations on the Upper Air Passages.—Typical examples of this complication are most frequently seen after

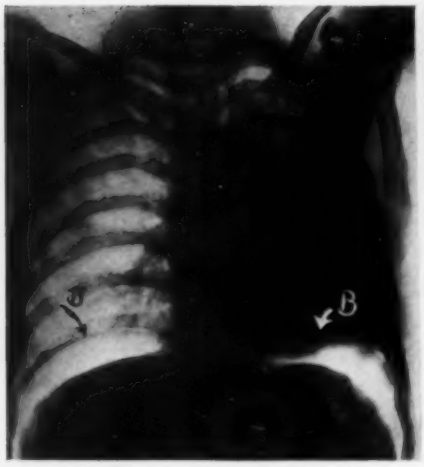

FIG. 1.

FIG. 2.

FIG. 1.—Röntgenogram of a man aged twenty-one years, showing atelectasis of the left lung that followed three days after appendectomy under spinal procaine anæsthesia. This type of post-operative complication follows abdominal operations, rarely, if ever, tonsillectomy or other operations on the upper air passages. The use of spinal anæsthesia eliminates inhaled ether as an etiological factor in this case. The air in the abdominal cavity (B) suggests the possibility that the abolition of the abdominal relations with the mechanism of respiration that normally exist so long as the abdomen is closed has a bearing on the etiology of post-operative atelectasis. This refers especially to conditions during the time the abdomen is open.

FIG. 2.—Here is seen the effect of promptly done bronchoscopical aspiration (C. L. J.).

tonsillectomy, but the same clinical features characterize the disease when it follows other operations about the upper air passages. [1, 2, 5] These clinical features are essentially different from those of pulmonary complications, especially atelectasis, following abdominal operations and totally different from

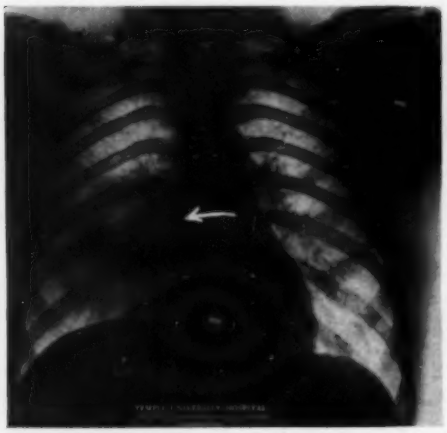

FIG. 3.

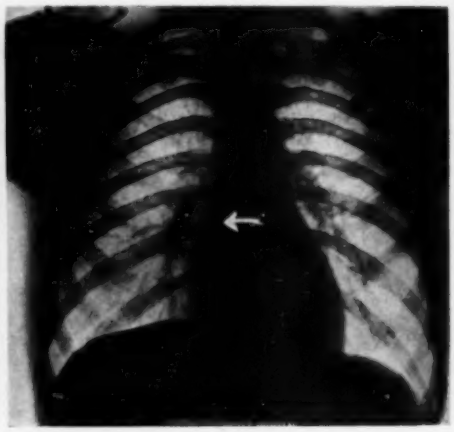

FIG. 4.

FIG. 3.—Röntgenogram of a man aged twenty-two years, showing shadows of a pulmonary abscess that followed six days after operation under ether, on the external nose for traumatic deformity. The pulmonary condition, sudden cavitation, as well as in its fulminating onset and other clinical features, was identical with what follows tonsillectomy. In this case the tonsils were extensively diseased but were not touched at operation. This and similar cases suggest that the question of the cause and route of infection in post-tonsillectomic pulmonary suppuration are closely linked with the larger question of descending upper respiratory infections independent of operation on the tonsil itself, or, indeed, of any operation.

FIG. 4.—After bronchoscopical aspiration (C. L. J.) the abscess was healed completely as shown here.

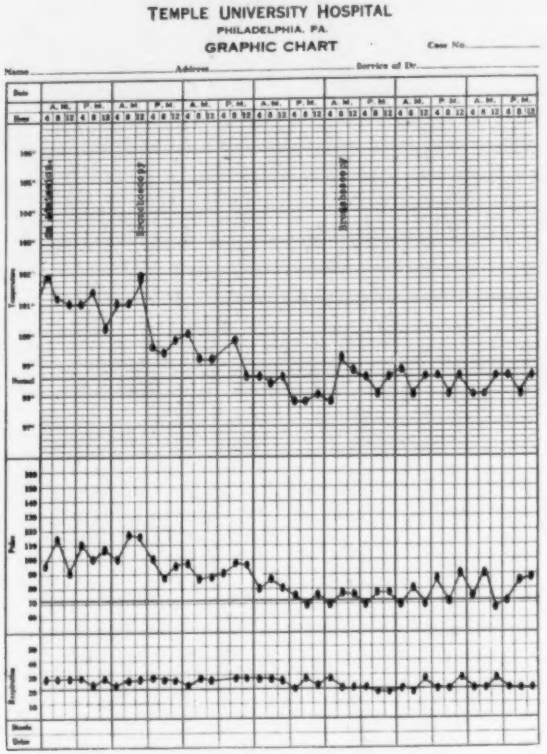

CHART 1.

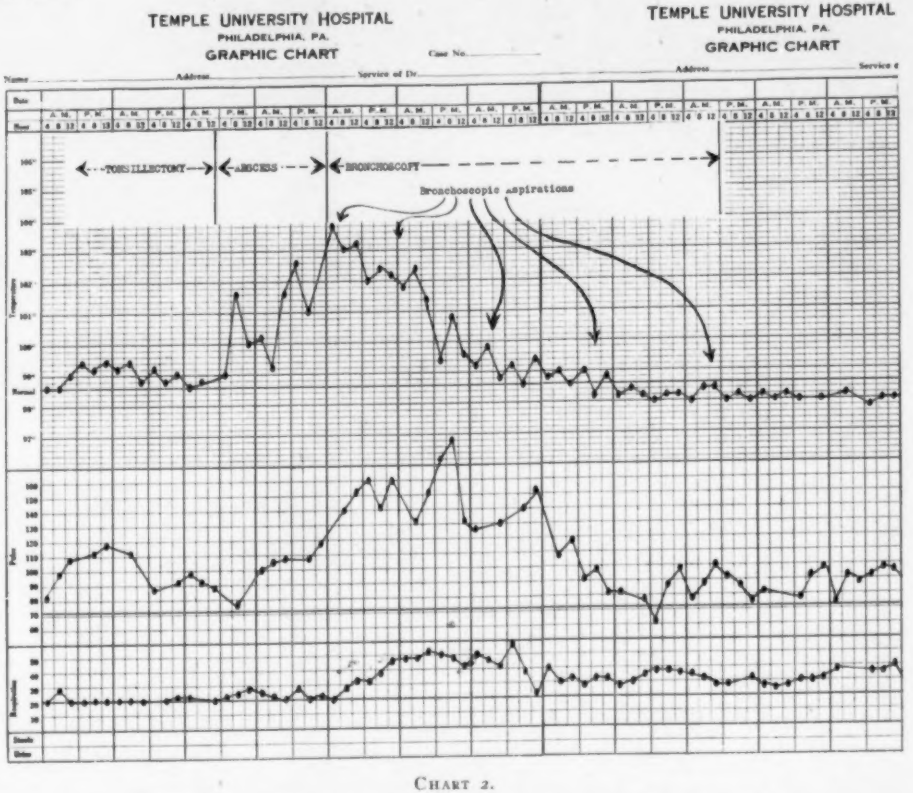

CHART 2.

CHART 1.—Temperature chart showing the result of bronchoscopical aspiration in the case of post-tonsillectomic abscess shown in Figs. 7 and 8.

CHART 2.—Showing graphically a typical fulminating onset of pulmonary abscess following tonsillectomy. The post-operative range was about the average and was commencing to subside when the abscess developed. Suddenly the temperature rose, accompanied by a chill, foul breath, and the expectoration of putrid, bloody pus. The abscess was increasing in size rapidly until progress was arrested by bronchoscopical aspiration. The prompt subsidence after bronchoscopical aspiration is typical of the result obtained in 80 per cent. of the cases in which the abscess is thus drained early.

those following the inspiration of foreign bodies at operation on the upper air passages.

In a typical case of pulmonary complication following tonsillectomy or other operation about the upper air passages, the patient is taken suddenly ill with prostration, high fever, chilliness within a week or ten days after operation. (Chart 2.) Among the initial symptoms there is expectoration of a rather large quantity of foul, usually bloody pus, the patient's breath is fetid and a röntgenogram at this stage always shows a localized inflammatory area and usually a cavity with fluid level. If such a level is not at once apparent it soon becomes recognizable; if bronchoscopical aspiration be done the cavity is seen to be evacuated and a fluid level is seen later as it refills. (Figs. 3, 4, 5, 6, 7 and 8.)

FIG. 5.

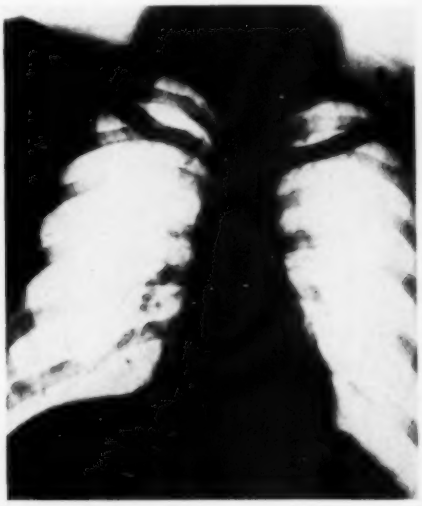

FIG. 6.

FIG. 5.—Röntgenogram of a man aged thirty-six years, showing a post-tonsillectomic abscess of the left upper lobe cured after eight bronchoscopical aspirations. (Aucoin.)

FIG. 6.—Röntgenogram after treatment. This is one of twenty-seven cases showing that the *upper* lobes can be efficiently drained by bronchoscopy when done without anæsthesia. The aspirating tube goes around the corner into the ascending upper lobe branches, but the most important factor is the "tussive squeeze" that forces the pus from the periphery toward the stem bronchi.

Pulmonary Complications Following Inspiration of Foreign Body at Operation.—It is not intended here to refer to the more than 1,500 cases of inspirated foreign body in the records of the clinic.[1, 6, 7, 9] In those cases the foreign body went through the mouth and necessarily carried infection. That the infection was not in any case followed by abscess such as we see after tonsillectomy is significant; but in most of those cases there were not the conditions that are present at a tonsillectomy, bleeding, inspiration of blood, anæsthesia, abolition of reflexes, especially the cough reflex, that might favor abscess formation. We wish to refer only to a class of case in which a foreign body was inspirated during tonsillectomy or other operation in the upper air passages, presumably accompanied by all the just mentioned conditions. A rather large number of the latter class of case have come to the

Bronchoscopic Clinic and from them some very interesting and important data have been accumulated.[1, 4, 7] The clinical features are quite different from the post-operative atelectasis following abdominal operations on the one hand and the sudden abscess formation with shock, high fever, prostration and profound sepsis, following tonsillectomy and nasal operations, on the other.

In a typical case of foreign body inspirated at operation the patient gives no sign of ill-health for a number of weeks or sometimes months afterward, depending on the character of the foreign body and especially the degree of obstruction its shape may enable it to produce. A non-obstructive piece of steel instrument may cause no symptoms for many months.[7] A tooth or piece of human bone[1] on the other hand usually causes a slight cough within a few days; within a few weeks there may be slight expectoration; in a few

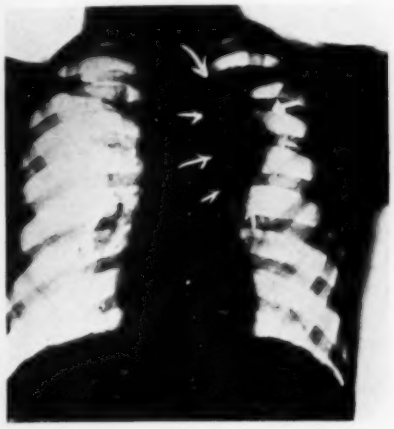

FIG. 7.

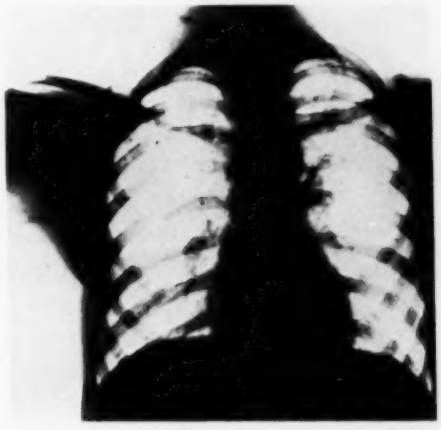

FIG. 8.

FIG. 7.—Röntgenogram of a boy aged thirteen years, showing a post-tonsillectomic abscess in the upper lobe near the root of the left lung. Because of the parahilar location the surgeon deemed thoracotomy contra-indicated and referred the patient to the bronchoscopical department.

FIG. 8.—This röntgenogram, taken after four bronchoscopical aspirations (C. L. J.), shows disappearance of the pathological shadows. The patient was and has since remained symptom-free. This is another one of the twenty-seven cases of upper lobe abscess demonstrating the high degree of efficiency of bronchoscopical aspiration of the upper lobe, when done without anæsthesia so as to obtain the aid of the tussive squeeze.

months some foul pus and a slightly fetid breath.[10] At this secondary stage the Röntgen-ray examination shows no cavity with fluid level.[10] Granulations and a localized suppurative bronchitis are found at bronchoscopy but this entirely disappears in a few weeks after bronchoscopical removal of the foreign body.[7, 10] If the foreign body be not removed until after many months in obstructive cases there may be a localized purulent collection but no abscess cavity with fluid level. Considering the fact that a carious tooth probably carries with it as great a variety of infective agents as are contained in the tonsil or the nasal cavities this endobronchial limitation of the suppurative process is in very striking contrast to the sudden parenchymal abscess formation seen in post-tonsillectomic cases unassociated with foreign body.[1]

These observations are based not upon a case or two but upon a relatively large series (47 cases) including teeth dislodged during exodontia[3] and ton-

FIG. 9.—Dental and surgical objects inspirated into the bronchi chiefly *during operations* in the upper air passages. Notwithstanding the facts that practically all must have carried infective agents, many must have carried blood with them and some were completely obstructive—notwithstanding these conditions, there was not, in a single instance, the fulminating abscess formation and clinical picture associated with post-tonsillectomic, parenchymal, pulmonary abscess. In all these cases complete recovery followed bronchoscopical removal with its incidental aspiration of pus or secretions. This clinical evidence is rather against the inspiratory origin of this type of pulmonary abscess. Additional series of cases may show exceptions, but it seems unlikely that this mass of evidence will be rendered less important.

sillectomy sponges from the tonsillar fossæ,[4] nasal rasps,[2] dental and tonsil instruments,[4] portions of turbinate and alveolar bones,[1] blood clots, *etc.*[8, 9] (Fig. 9). These cases have been reported in the articles to which references are appended. There is one recent case, however, that presents so many remarkable and important features apropos of the present subject that it is here given.

CASE I. (Fbdy. 2795.) *Portion of tonsil removed bronchoscopically from the left lower-lobe bronchus after seven months' sojourn in a girl aged seven years.* For three months after tonsillectomy there were no symptoms. Then slight cough, dry at first, appeared and gradually became somewhat productive. Occasional slight elevation of

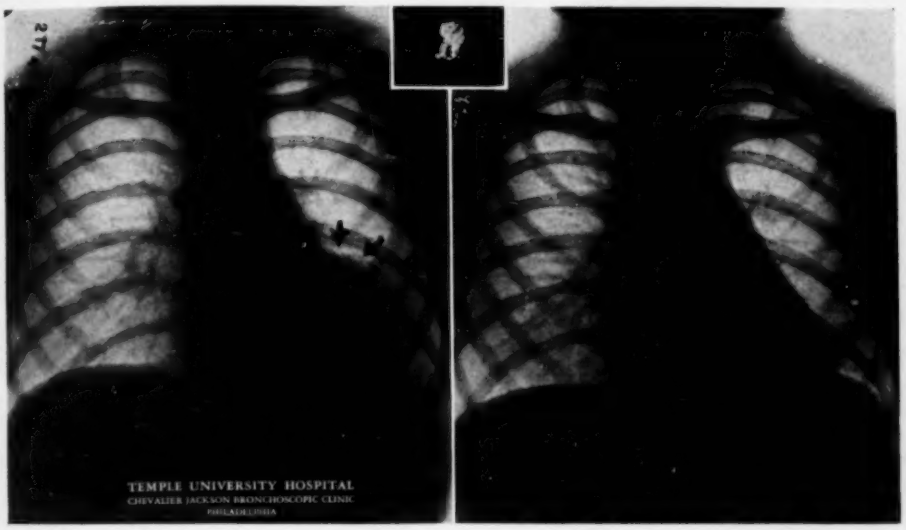

FIG. 10. FIG. 11.

FIG. 10.—Röntgenogram showing a slight shadow of atelectasis and drowned lung due to the seven months' sojourn of a tonsil in the left bronchus. Notwithstanding the probable presence of blood clots, the prolonged obstruction of a bronchus by the tightly fitting plug of tonsillar tissue filled with septic material no ill-health sufficient to keep the child out of school resulted, and not one of the clinical features of post-tonsillectomic pulmonary abscess were present. The symptomless interval of two months, the mildness of the symptoms when they did develop and the prompt recovery after bronchoscopical removal were all features commonly seen in non-septic, bronchially lodged foreign bodies. They are in marked contrast to the fulminating onset of post-tonsillectomic pulmonary abscess (Chart 2), and they point to the previously noted[10] great defensive power of the lung against invasion by way of the bronchial mucosa.

FIG. 11.—Röntgenogram of the same patient as in Fig. 10, showing the complete disappearance of the pathological shadow in three weeks after bronchoscopical removal of the tonsil that had been in the lung for seven months. The inset is from a photograph of the tonsil reduced in the same proportion as the röntgenogram.

temperature was noted during the sixth and seventh month after tonsillectomy. The father who is a physician had a Röntgen-ray examination made; it revealed atelectasis of the left lower lobe. He then brought the child to the Bronchoscopic Clinic of Temple University Hospital seven months after tonsillectomy. On admission the child had a moderate and slightly productive cough, temperature, 99.4°. She did not seem ill, and certainly was not toxic. Röntgen-ray and physical examinations indicated atelectasis or drowned lung, or both, in the left lower lobe. (Figs. 10 and 11.)

Bronchoscopy without anæsthesia, general or local, revealed a small amount of pus in the trachea. This was found to come from the left bronchus. After aspirating this, a whitish nodular obstruction was found occluding the left lower-lobe stem below the orifice of the left upper lobe bronchus. This was removed with side-bent forceps, liberat-

ing a small amount of pus which was aspirated. A slightly unpleasant odor was noted but it was not foul. Upon examination of the nodular soft foreign body it was found to be tissue grossly resembling the amputated portion of a tonsil; it was not putrid. Microscopical examination by Dr. Frank R. Konselmann, pathologist of Temple University Hospital, showed the specimen to be made up of tissue infiltrated with lymphocytes. The stroma was well preserved but the lymphoid structure was largely replaced by chronic inflammatory tissue. Progress after removal was uneventful. At the end of two months, cough, expectoration and all other symptoms had ceased without treatment other than an outdoor régime. A röntgenogram showed complete disappearance of all pathological shadows. (Fig. 11.)

Comment.—It seems remarkable that so septic a thing as a mass of tonsillar tissue should remain in a bronchus for seven months without being destroyed, without becoming putrid and without producing a violent suppurative reaction with abscess formation in the invaded lung. Every clinical feature of the case resembled the usual slowly developing pathology of foreign body in the bronchus and was in marked contrast to the sudden abscess formation and fulminating onset of post-tonsillectomic abscess unassociated with foreign body. All of the etiological factors deemed essential for the production of abscess were present, bronchial obstruction, blood-clots, prolonged contact of a relatively large quantity of septic material held in the tonsil itself. It seems reasonable to suppose that if a minute piece of that tonsil had been introduced into a tonsillar vein pulmonary abscess from septic infarct would have resulted, because the infection would have thus been introduced behind the epithelial barrier of the bronchial mucosa.

Inspiration of Blood at Operation.—Undoubtedly, blood is inspirated at nearly every tonsillectomy. The anterior and downward displacement of the tongue with the tongue depressor necessary to expose the tonsil to view creates a funnel the bottom of which is the always open larynx; but what seems of even greater importance is the fact that so long as the tongue is held down the patient cannot readily swallow, because the first swallowing movement normally is the rising of the tongue to the roof of the mouth. Some blood is swallowed in the intervals between depressions of the tongue and afterward; but during the depressions what is not aspirated by the surgeon is inspirated into the tracheobronchial tree by the patient. The mechanism involved is easily demonstrated; if a person not anæsthetized attempts to swallow water while the tongue is instrumentally depressed he cannot swallow and he will usually choke and strangle from the entrance of fluid into the larynx. Though blood is inspirated into the tracheobronchial tree at almost every tonsil operation under general anæsthesia it does not necessarily follow that post-tonsillectomic abscess is necessarily due to the inspiration of blood and infective materials. The relative rarity of abscess is rather against this as the route; and anyway demonstrates, again,[10] the marvelous defensive power of the lung against infective invasion by way of the bronchial mucosa.

The Bronchiectatic Septic Tank.—Bronchiectasis is, in some cases, a tertiary sequel of operation. Developing slowly after a post-operative atelectasis or suppurative pulmonary condition, and being practically always

associated with a focal infection in the sinuses or lymphoid tissue, it is always a question whether or not bronchiectasis would have developed anyway; it is clear that there must be other etiological factors. Chief of these is the bronchiectatic septic tank. By this is meant nature's way of getting rid of thick viscid secretions by first thinning them by putrefactive processes.[11] The products and by-products of these changes though rendered easy of expulsion are intensely irritating to the bronchial walls and constitute one of the factors in the changes in those walls as well as in the perpetuation of the disease. The existence of the bronchiectatic septic tank has been demonstrated by bronchoscopical studies and these studies have demonstrated that it can be eliminated by bronchoscopical aspiration done before the thickened secretions undergo putrefaction.[11]

Sedatives.—The tendency to regard cough as like pain, a thing to be suppressed with sedatives, is an error; it is a natural defensive reflex, the watchdog of the lungs, not only guarding against invasion but, aided by the bechic blast and the tussive squeeze, repelling intruders that have gained access. The suggestion that the cough reflex should be abolished because it helps to scatter infection ignores the fact that it is unthinkable and impossible to abolish it forever; sooner or later the patient must cough, if he survives the operation, and when he does whatever scattering may be done by cough will then be done after long sojourn. It would seem more logical to depend upon uninterrupted cough to get rid of the scattered as well as the unscattered material promptly, just as the florist by many compressions empties the sprinkling bulb, sucking in air between compressions. Atropine lowers tussive efficiency by increasing viscosity. Its use before, during or after operations is illogical and unnecessary.

CONCLUSIONS

(1) Observations on cases referred to the Bronchoscopic Clinic for diagnosis and treatment of post-operative pulmonary complications show certain contrasts that would seem to have an important bearing on the etiology, diagnosis, prophylaxis and treatment of this class of pulmonary diseases.

(2) Post-operative atelectasis in almost all of our cases had followed addominal operations; it is a condition not primarily suppurative; when suppuration follows later it is endobronchial and may eventually end in drowned lung if unrelieved. The obstructive bronchial secretions causing the atelectasis contain an excess of fibrin, but few pus cells, grossly no pus and few, if any, pyogenic bacteria.

(3) Post-operative foreign body such as a tooth, a human bone, a nasal, dental or tonsillar instrument or a portion of tonsil does not primarily produce a purulent lesion. The onset of suppuration is gradual, often requiring months, and the pus-formation is strictly endobronchial. This is remarkable and important when one considers the resultant obstruction as well as the blood and infective material that all such foreign bodies must carry with them into the bronchi.

(4) Pulmonary complications following operations on the tonsils and upper air passages are suppurative from the onset; the start is sudden, often fulminating; the suppuration is usually a parenchymal abscess emptying into a bronchus. This is in strong contrast to the non-suppurative onset in cases of post-operative atelectasis on the one hand and of post-operative foreign body on the other.[2]

(5) The logical conclusion from these contrasts is that post-tonsillectomic abscess is not usually an inspiratory infection but an infective embolic process. However, it would not be wise to say that inspiratory infective processes could not in any case produce such an abscess.

(6) Bronchoscopy is strongly indicated at the earliest possible moment in all varieties of post-operative pulmonary complications. To say that bronchoscopical aspiration is not needed in any case on the basis of recoveries without it is equivalent to saying transfusion is not necessary because of recoveries in cases where it was indicated but not given. The improved condition of the patient after bronchoscopical aspiration, for post-operative atelectasis is just as striking as that in a patient after a much-needed transfusion of blood.

(7) In post-tonsillectomic abscess the cilia are overwhelmed by the dumping into the bronchi of a large quantity of thick pus from a parenchymal abscess. Bronchoscopical aspiration takes the load off the cilia and restores the defensive powers of the lung by reëstablishing ventilation and drainage.

(8) Bronchoscopical aspiration is supplemented by the "tussive squeeze." That is, the compression of the lung during cough squeezes the pus out of the parenchyma and smallest bronchi to within the reach of the aspirating tube. It is not necessary that the tube be always inserted into the abscess cavity or out to the periphery of the upper lobe. The tussive squeeze empties the upper lobe into the main bronchus.[11]

(9) The prophylaxis of atelectasis consists in (*a*) avoidance of sedatives, such as morphine and codein, that lessen the tussive squeeze and bechic blast, and of drugs such as atropine, that increase viscosity of secretions; (*b*) avoidance of operations during or shortly after influenza and other acute respiratory infections; (*c*) examination of the nasal sinuses and larynx before every operation; (*d*) Röntgen-ray examination of the chest before every major operation. This would also eliminate post-operative blame for pre-operative pathology.

(10) It is a fallacy to arrest the cough reflex during operations in an effort to prevent scattering of infective or obstructive materials. The patient must cough sooner or later and will then have an accumulation to scatter. Scattering of infective materials by cough is of no consequence if the cough reflex is free to work unhampered by sedatives.

(11) Once suppuration is established the prophylaxis of bronchiectasis depends largely upon elimination of the bronchiectatic septic tank by aspirating the thick, viscid pus without allowing it to wait for putrefactive processes to thin it in order to facilitate its tussive expulsion.[11]

(12) The instrumental depression of the tongue at tonsillectomy prevents swallowing and creates a funnel leading to the always open larynx. The result is that blood and infective materials are inspirated into the tracheobronchial tree at practically every tonsil operation; if this is the route followed by the infection causing post-operative pulmonary abscess the rarity of such a sequel is evidence of a most marvelous defensive power of the lung against infective invasion by way of the bronchial mucosa.

(13) Bearing on the question as to which of the various routes is traversed by the infective agent in the pathogenesis of post-tonsillectomic abscess, (*a*) air passages, (*b*) blood-vessels, (*c*) lymph channels, (*d*) air passages plus bronchial lymph channels, (*e*) lymph vessels plus peritonsillar veins, our observations indicate that whereas the treatment is clearly indicated the etiology, pathogenesis and prohpylaxis of the post-operative pulmonary suppuration are intimately involved with the as yet unsettled larger question of descending upper respiratory infections in patients not operated upon.

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PENETRATING STAB WOUNDS AND BULLET WOUNDS OF THE CHEST

A STUDY OF SIXTY-EIGHT CASES OPERATED UPON BETWEEN JUNE 1, 1931, AND APRIL 30, 1932, WITH A DESCRIPTION OF A NEW OPERATIVE PROCEDURE OF EXTRAPLEURALIZATION AND EXTERIORIZATION OF THE PULMONARY LACERATION*

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Until June, 1931, the treatment at the Harlem Hospital of penetrating wounds of the chest was not different from that in most other hospitals. That is to say, the superficial wound was either closed by suture or packed with gauze. The patient was observed for complications which might require further treatment. It is true that a great many patients were cured without further intervention other than simple closure, but not infrequently it was found that patients who did well at first soon succumbed to hæmorrhage or infection, in spite of frantic efforts to remedy the damage. Indeed, we were so much impressed by the deaths of three patients from seemingly preventable causes within a period of two weeks in May, 1931, that the senior author decided that all cases should be operated upon on admission to the hospital to arrest hæmorrhage from the internal mammary and the intercostal arteries, if severed.

Case I.—One of the three deaths was in the case of a patient admitted with a stab wound in the right second intercostal space close to the sternal border. He showed signs of marked hæmorrhage but his pulse became normal and his condition improved after an injection of physiological saline solution and the administration of morphine. He was placed in the Trendelenburg position and wrapped with warm blankets. For a few hours he seemed to be improving. This improvement, however, gave us a false sense of security, because after four or five hours he was dead from a tremendous intrapleural hæmorrhage demonstrated at post-mortem examination.

Apparently bleeding had stopped temporarily in this case because the initial hæmorrhage had lowered arterial pressure sufficiently to prevent much flow from the severed internal mammary artery. The supportive treatment instituted produced an increase in arterial pressure sufficient to start bleeding again. With the second hæmorrhage, in a patient already almost exsanguinated, death followed soon. Our subsequent experiences led us to believe that if the severed internal mammary artery had been controlled by ligature before the second hæmorrhage occurred the patient's chances would have been greatly enhanced. The sequence, (1) *hæmorrhage and collapse* followed by (2) *improvement in the condition* of the patient by rest and supportive treatment, and (3) *a second hæmorrhage and collapse* due to improved arterial force, followed by (4) *death*, is not uncommon.

Case II.—This patient received a stab wound in the left third intercostal space about one inch from the left sternal border. He progressed comparatively well for a period of

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eight days when a hemothorax which he had originally developed became infected. The wound had been treated with simple suture and the patient bore the infected hemothorax well as long as the wound remained closed. However, when the wound broke down, pus poured forth, and a sucking wound developed with marked cardiac and pulmonary embarrassment. Many devices were tried in an attempt to make air-tight drainage through this infected orifice but without success.

Several factors entered in the death of this patient, the most important of which was a sucking wound permitting displacement of the mediastinum, collapse of the left lung and partial collapse of the right lung, which produced a decrease in pulmonary ventilation. The abnormal position of, and pressure upon, the heart and great vessels increased the embarrassment of circulation.

Case III.—A young woman was stabbed in the third left intercostal space close to the border of the sternum. The wound was closed by suture. She developed a large hemothorax which became infected. On the fifth day it was drained with a tube through a counter incision at a dependent portion of the pleural cavity and the tube was placed under water. Air-tight drainage was difficult to maintain. The patient became rapidly worse, showing signs of marked collapse and toxæmia leading to death. The problem here was similar to that of Case II. In all these cases, last-minute heroic measures to save the patient were quite useless.

With these cases in mind we abandoned the *laissez faire* method of treatment (which characterizes the first period in mode of treatment) and entered upon the second period, in which we operated by various methods upon thirty-two patients. In this group, many data were accumulated and two entirely new operative procedures were developed by the junior author. After the operation of exteriorization of the lung was developed it was employed routinely (third period) and when thirty-two patients had been operated upon the results of the three periods were compared.

In the *first period*, June 1, 1930, to May 31, 1931, there were forty-five cases of penetrating wounds of the chest with eleven deaths, mortality 24.4 per cent.

In the *second period*, June 1, 1931, to November 10, 1931, there were thirty-two cases with seven deaths, mortality 21.8 per cent.

In the *third period*, November 11, 1931, to April 21, 1932, there were thirty-two cases with four deaths, mortality 12.5 per cent.

In the entire period there were five wounds of the heart. In each instance the patient died.

The Examination of Patients upon Admission.—The patient usually presents a single wound. Frequently it is impossible to determine whether the thorax was penetrated. Some of the so-called cardinal signs of penetration have been found in non-penetrating wounds, while frequently, in the early hours, penetrating wounds showed no signs of penetration. In three cases we saw patients on admission present signs of marked collapse, a picture which we learned to associate in these cases with severe bleeding and with large hemothorax; nevertheless, operation revealed no penetration through the chest-wall.

Additional misleading phenomena are the following; a sucking wound may occur without penetration when forced respirations cause air, beneath

the large muscles of the chest-wall to pass back and forth through a superficial wound. Subcutaneous crepitation has been misleading when it was due to air sucked into the wound and then forced under the skin. Sometimes a blood clot gives crepitus. Even pneumothorax demonstrated in röntgenograms measured with a pneumothorax apparatus was found in a case in which the wound did not penetrate beyond the intercostal muscles. In one case the X-ray film showed a shadow which usually is interpreted as fluid but operation proved that it was due to old fibrous adhesions between visceral and parietal pleuras.

We do not desire to give the impression that these exceptions to the cardinal signs are common, but merely wish to call attention to the fact that they may occur.

The clinical picture on admission frequently does not indicate the extent of internal injury. Physical signs have been of value in only a small number of the cases. The clinical picture may be obscured if the patient has taken excessive quantities of food and liquor. The same difficulty that is found in distinguishing acute alcoholism from those conditions in the abdomen requiring surgical intervention arises in thoracic injuries. In two instances, patients collapsed while being X-rayed. This was interpreted as internal hæmorrhage but operation revealed penetration and no hæmorrhage.

In three cases we observed a sign which we have never seen described. At a place about one to one and one-half inches caudad to the wound of penetration in the skin a ballooning occurred causing the skin to rise and fall with respiration. This billowy motion beneath the skin took place within an area one and one-half to three inches in diameter. There was no escape of air through the wound. We found this to be a true sign of penetration, since air must escape through the parietal pleura to cause it. A barrier of muscle prevented escape of air through the skin wound.

In 66 per cent. of cases, *i.e.,* sixty-nine out of 109, the X-ray picture taken pre-operatively indicated a pathological condition. In 25 per cent. of cases there was a shadow suggestive of hemothorax, although (as has been mentioned) one case proved to be a fibrotic or thickened pleura. In 11 per cent. of cases there were signs of hemopneumothorax and in one case pneumothorax unaccompanied by fluid. An interesting finding is the shadow produced by a wound in the lung itself by a bullet. This shadow remains discrete in the lung tissue and is surrounded by an area of aërated lung. In addition, there may be another shadow at a dependent portion indicating fluid in the free pleural cavity.

Implements of Penetration.—The commonest type of implement in our experience is the so-called "switch blade," a pocket knife with a long, narrow, strong, sharp and pointed blade. This may produce an apparently innocent external wound and yet do great damage beneath the skin. In comparison, the ordinary pocket knife is rather a harmless thing, which may penetrate the chest-wall, but seldom causes trouble beneath it. The ordinary table knife of broad blade, partially stopped by the ribs, frequently does less

damage than might be expected. The ice pick, which is occasionally used, unless it has struck the heart, is least harmful.

Bullets do more damage than stab wounds but fewer cases are brought to the hospital because death occurs so rapidly that the victims cannot be reached in time for treatment.

Wounds.—The abrasion at the edge of the bullet wound tells the direction from which the bullet came. A wound of exit may also help to indicate what visceral injury has occurred. On the contrary, stab wounds, however, give no sign of the direction of the laceration of the chest-wall. We have carefully studied the contour of stab wounds in order to determine before operation the direction of the path of the knife, but we were unsuccessful. Our operative procedures have taught us that stab wounds usually enter the pleura at a point caudad to the wound of entrance in the skin (indeed, sometimes a distance of two ribs below). When produced by a right-handed

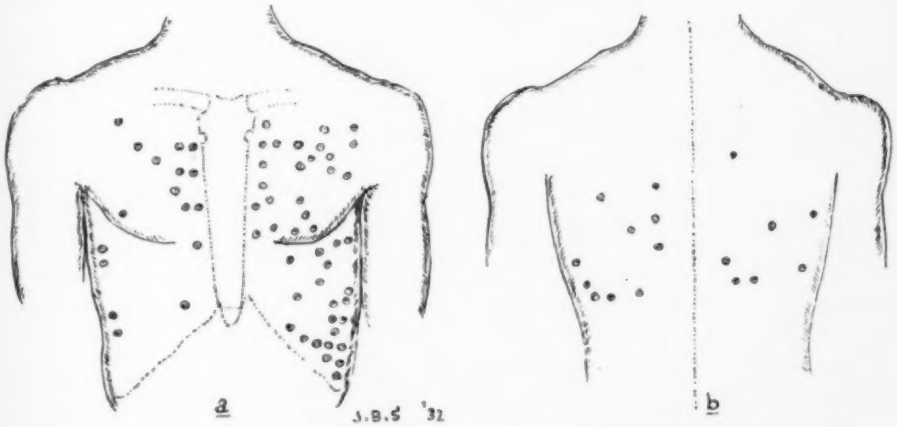

FIG. 1.—Anterior (*a*) and posterior (*b*) distribution of penetrating wounds. Note the frequency of penetration over the dangerous parasternal and diaphragmatic areas.

assailant the wound will proceed from the assailant's right to left. In making our exploratory incision we disregard the wound of entrance in the skin, and incise at a level an inch or an inch and a half below it. Wounds made in this manner produce incisions at different level of skin and pleura, and thus create a valve which may account for the infrequency of sucking wounds.

Wounds may be "sucking" or bleeding profusely or emit foamy blood with respiration but in the majority of cases they are entirely "silent" and afford no clue to the underlying injury. However, in the second and third periods of our investigation we did not depend upon signs of penetration. All cases in which consent was obtained were operated upon.

In Fig. 1 is shown the distribution of wounds upon the chest-wall. Most of them are on the left side, as might be expected, since most assailants are right-handed and the victim presents the left anterior chest-wall and axilla to the assailant. The distribution of wounds has, of course, an important rela-

tion to underlying structures. The majority are in such a position that the weapon may reach the internal mammary artery, the heart, or the diaphragm.

A stab wound in the pleura is frequently larger than the corresponding wound in the skin. It may be twice or three times as large. Some assailants penetrate the chest and then, with a motion of the wrist, rock the blade back and forth. This is one of the reasons why the skin incision offers no clue to the damage beneath it. A costal cartilage or the rib near it may be completely severed by a subcutaneous knife cut. A knife may hit the sternum and cause a wound which appears innocent because the sternum is directly beneath it, and yet the knife may have slipped from the sternum through the cartilaginous portion of the rib or between the ribs.

Complications and Causes of Death.—In our study the most valuable information that we have gained has been from observations and analysis of complications and from a study of the causes of death. By these data and by the practical method of being confronted with abnormalities at operation which required correction, we have been able to arrive at our present procedure.

Mechanical Factors.—(1) *Sucking Wounds.*—The ill effect of sucking wounds is well known. The embarrassment of circulation and respiration is terrifying. Equally striking is the immediate relief usually obtained by stoppering the orifice. But even when a sucking wound has been stoppered an intra-thoracic disturbance may have already taken place and progress to such an extent that the patient's margin of safety is diminished.

The disturbance of the mediastinum plays a part during life which cannot be given as a cause of death by the Medical Examiner since it usually cannot be recognized on post-mortem examination. The mechanism may be observed by the surgeon upon entering the chest cavity, as he sees the heart and the great vessels and the lung flap without rhythm. He may see the patient stop breathing and see the heart stop beating unless the mediastinum has been steadied by traction on the lung. If the heart stops and respiration ceases, steady traction on the mediastinum by grasping the lung may restore function.

Even when it has been closed a wound may break down as a result of infection and then it is impossible to close it. This infection may be brought about primarily from without or may result from an infected hemothorax dissecting its way from within.

(2) *Subcutaneous Emphysema.*—Subcutaneous emphysema or crepitation occurred in 40 per cent. of our cases. In all but four cases it was accompanied by penetration. It varied in extent from an area two inches in diameter to one involving the entire trunk, arms, and head. There was no trouble except in one case, in the first period. In this instance the air producing the subcutaneous emphysema issued from an intercostal stab wound and spread rapidly over the body above the waist line and in the mediastinum and caused alarming interference with breathing and swallowing. There were dyspnœa and cyanosis and death appeared imminent. However, after closure, by suture, of the intercostal muscles, the spread of the emphysema

was stopped and the patient went on to a perfect recovery. This was the only case since June 1, 1930, that required operative interference on account of subcutaneous emphysema. No palliative treatment of multiple skin incisions was made but the cause was attacked and removed.

(3) *Pneumothorax.*—In all penetrating wounds of the chest varying degrees of pneumothorax occur. In most cases it is small and of no practical importance. In our pre-operative X-ray examinations we found it present in only 12 per cent. of the cases. Routine examination by means of the pneumothorax apparatus during our second period demonstrated that it was usually present. In many cases in which the X-ray film showed no pneumothorax, the actual reading of the pressure in the chest showed variations from normal, usually a low negative pressure. Obviously the negative X-ray film does not rule out the presence of small amounts of air in the pleura. When post-operative readings were made during our second period, they were made in order to determine the possible existence of a tense pneumothorax. At present, we seldom find it necessary to measure the intra-thoracic pressure because a tense pneumothorax cannot occur when we have exteriorized the wounded lung. Whenever it occurred we were able to relieve it by employing the pneumothorax apparatus and removing measured amounts of air until the desired pressure was attained.

Negative X-ray films may be due in part to the fact that the pneumothorax is localized anteriorly or posteriorly as a result of adhesions and therefore it may not be revealed in the anteroposterior or postero-anterior films. It is possible that the films have been exposed when the lung temporarily filled the pleural cavity. In one case pneumothorax occurred on the side of the stab wound, but careful dissection showed no penetration into the pleural cavity. In another case pneumothorax was found in the side opposite to the stab wound.

A tense pneumothorax may be a serious condition, causing marked discomfort and even end in death. A pneumothorax may cause disturbance not only by tension, but may also contribute to a subsequent pneumonia. This occurs, we believe, in the following way:

The lung on the side of penetration is frequently completely collapsed and the opposite lung is partially collapsed because of the shift in the mediastinum. The compressed or collapsed lung has a deficient circulation and therefore is easily infected. Death may follow easily from the toxæmia of infection, because the compression and collapse have greatly diminished the amount of available aërated lung.

In a case complicated by a large hemothorax, a pneumothorax was superimposed through infection of the blood in the chest with a gas-producing bacterium, and gas with the odor of hydrogen sulphide was aspirated.

A pneumothorax does not occur, of course, in those cases in which the pleural cavity has been obliterated by adhesions of a previous inflammatory process such as empyæma. Percussion and auscultation were not very

dependable in the diagnosis of pneumothorax in our traumatic cases and we depended rather upon thoracentesis.

(4) *Hæmorrhage.*—Bleeding from the chest-wall occurs from the superficial blood-vessels and from the intercostal and internal mammary arteries. The first source is of no clinical importance since it produces at worst a large hematoma. Bleeding from the internal mammary and the intercostal vessels may be very troublesome, and, indeed, cause death by large hæmorrhage into the pleural cavity. Severance of the internal mammary vessels is far more dangerous than injury to the intercostals.

The heart in four cases, the pericardium in two cases, the lungs frequently, and the diaphragm in one case, were the sources of much intrapleural hæmorrhage.

Massive hæmorrhage from the lung occurred frequently in our second period as demonstrated by the fact that in cases in which we had securely tied the intercostal vessels and emptied the pleural cavity of blood, a large hemothorax developed subsequently. In no case did we crush the intercostal vessel against the rib, as has been suggested, but after rib resection we ligated the vessel and placed packing down to it.

We have observed bleeding from the lung even after it was completely collapsed. We have realized the possible ill effects of allowing blood to remain in the pleural cavity where it may produce pressure or become the seat of infection, and we always attempt to remove all of it at operation.

It is not uncommon to find no signs of hemothorax even upon aspiration of the chest and yet after the struggle during the induction of anæsthesia an operation may reveal that a large hemothorax has developed. Frequently blood in the pleural cavity accumulates to such an extent that it exerts sufficient pressure to prevent further bleeding, and the patient may recover. If the blood is not aspirated, the hemothorax may become entirely absorbed or become organized with partial collapse of the lung. Frequently, if the collection of blood is not large, a single aspiration that is done for diagnostic purposes seems to occasion rapid absorption and disappearance of the hemothorax.

In the course of a hemothorax fever is frequently found ranging between 101° F. and 102° F., and may disappear spontaneously. A hemothorax may become infected. In one case, part of the hemothorax became purulent while another part was clear on gross examination. There was a wall of clot between them.

In entering for the purpose of exploring a pleural cavity in which a massive hæmorrhage has taken place, great care must be exercised. In one of our cases, a sudden large operative incision into the pleural cavity produced immediate cessation of respiration, a phenomenon familiar on occasion in cases of empyæma.

Hemoptysis.—Hemoptysis is a rare occurrence. Even in many of the cases in which on exposure large lacerations of the lung with broad bleeding surfaces were found, hemoptysis did not occur. In fact, it occurred only

twice in our entire series of cases, one in which the patient was stabbed with an ice pick and the other in which the patient had a diffuse pulmonary tuberculosis dating from childhood.

(5) *Infection.*—Infection played an important rôle in the second period in which as a rule only the chest-wall was repaired. In the third period infection played a minor rôle.

(*a*) *Chest-wall.*—Infection of the chest-wall, while fairly frequent, was extremely mild except in one case in which there was a through-and-through bullet wound of the left chest and lung. In this case an intrathoracic injury was corrected but a phlegmon of the chest-wall led to sepsis and death one week after operation. Infections of the chest-wall may involve either the fascia, the periosteum, or the parietal pleura, but are so mild that they cause no fever and the patient may be ambulatory or return to work.

(*b*) *Pleura.*—We are impressed by the fact that infection of the pleura is not in itself an important cause of death. In our third period we instituted a new operative procedure and pleural infection took place in only 6 per cent. of the cases, whereas in the second period it took place in 20 per cent. of the cases. Rarely does it cause death of itself but acts as a factor in causing death when other factors have not been corrected. It may be introduced from without at the time the patient is stabbed. A dirty knife, unclean clothes and an unclean skin present three sources of bacteria.

Infection may come from the lung which has been lacerated and in which a suppurative process takes place, later infecting the pleural cavity. It may take place in case a chest-wound is sutured and later breaks down allowing bacteria to be introduced from the outside. Also, it may arise from infection which has grown rapidly in the blood of a hemothorax, in this way producing a pyothorax and a purulent pleurisy.

A differentiation should be made between an infected hemothorax or pleura and a true empyæma thoracis. The term empyæma thoracis should not be used, we believe, to designate an infected hemothorax. There are two different conditions and the difference is not purely academic. An empyæma thoracis originates in a superficial lung infection in individuals who usually become weak and anæmic as a result of long-standing infection. In infected hemothorax the patient usually has been robust and the lung is not the seat of primary infection and so he is able with ease to take care of the infected blood in the pleural cavity.

(*c*) *Lung.*—Although we believe that cases of late hemothorax may arise from infected lacerated lung, we have had only one opportunity to observe this phenomenon. The case will be described later.

Cerebral embolism was a post-operative complication in two cases. There was present coma and unilateral paralysis together with other symptoms of less importance clinically. In both instances the patient recovered, one symptom-free, the other with hemiparesis.

Visceral Injury.—Heart.—During the second and third periods, there were four penetrating wounds of the heart.

Diaphragm.—In the second period of thirty-two cases there were six cases of penetration of the diaphragm, five of which were repaired and one that was discovered at autopsy. In the third period there were five cases of penetration of the diaphragm and in one of the cases there were three lacerations. In none of our stab wounds did we find intra-abdominal injuries though the diaphragm was penetrated. On the contrary, in the bullet wounds penetrating the diaphragm, intra-abdominal injuries were found involving the stomach, small intestine, the liver, the spleen, the omentum, and the mesenteric vessels. In each case except one the diaphragm was successfully sutured. In three cases we extended the lacerations in the diaphragm and explored the upper portion of the abdomen on the left side through it. This, of course, is not advisable as a routine.

All the penetrating wounds of the diaphragm except one were on the left side. On the right side, lacerations of the diaphragm are of less importance because of the liver, which acts as a protecting barrier. One of the stab wounds which penetrated the diaphragm entered the skin at the level of the nipple and another one inch above the nipple.

Lung.—In the second period where only the chest-wall as a rule was operated upon, laceration of the lung was noted in only three cases in a total of thirty-two, while in the third period twenty-four cases of laceration of the lung were noted in a total of thirty-two cases. In this third period the lung in every instance was carefully examined for laceration while in the second period only a glimpse of the lung could be had through the small opening. The size of the lacerations varied from a superficial puncture to a laceration which extended from the border of the lung inward for a distance of three inches and involving its entire thickness.

Causes of Death.—The important factors causing death may be best demonstrated in a discussion of cases. The records in the first period, that is, before routine operations were introduced, show eleven deaths in forty-five cases. It is difficult to determine the exact cause of death in these cases because autopsies were not seen by us, and the examination of charts and records of patients who have not been observed personally is not reliable. However, the impression gained was that the majority of deaths was due to hæmorrhage while infection was of less importance.

In the second period (in which we were attempting to find a logical operative procedure) of thirty-two patients, seven died. And in the third period (in which our operative procedure, to be described later, was employed) there were four deaths among thirty-two cases.

In addition, during the second and third periods there were six cases without operation with one death, and four heart wounds with four deaths.

Causes of Death in the Second Period.—Case I.—The patient was stabbed in the right second interspace close to the sternum. There was a massive hemothorax apparently arising from a severed internal mammary artery. The chest was rather suddenly opened through a large incision. The patient collapsed and in spite of a transfusion of 1,000 cubic centimetres of blood and an infusion of 3,000 cubic centimetres of physi-

ological saline solution, she died. The factors causing death were hæmorrhage, sudden opening of the chest cavity, with disturbance of the mediastinum, and recurrence of hæmorrhage.

CASE II.—There was a stab wound of the left anterior axillary line penetrating the diaphragm. The lacerations in the diaphragm and in the chest-wall were firmly sutured. The abdomen was explored through a separate incision and no injury was found. Three days after operation the patient developed pneumonia on the *right* side and died in two days. In this case the left lung at post-mortem was found completely collapsed. The pneumonia and subsequent death were favored by the pneumothorax, the collapse of the left lung, and compression of the right lung.

CASE III.—This patient had bilateral stab wounds. The intercostal vessels on each side were ligated, and the patient was quite comfortable until the sixth post-operative day, when he suddenly became dyspnœic, apprehensive, went into collapse and died. At autopsy a tense pneumothorax was found on the left side so great that the diaphragm and the liver were pushed down to the pelvis and air escaped with a hissing sound on section of the thorax. This patient died of the mechanical effect of a tense pneumothorax upon the lungs, the heart and the great vessels of the mediastinum.

CASE IV.—A stab wound penetrated the chest-wall in the left axilla and lacerated the left lower lobe. When the pleural cavity was entered, the lung collapsed, but bleeding continued from the lacerated portion. A mattress suture failed to stop the bleeding and therefore a free piece of muscle taken from the chest-wall was placed over the laceration and held in the place by a few sutures. Bleeding was controlled. The patient had an extremely easy convalescence until the twelfth post-operative day, when a slight hemoptysis occurred, followed in an hour by a massive hemoptysis and bleeding into the pleural cavity. Death occurred soon. At autopsy, in addition to the hæmorrhage, a small abscess was found in the region of the laceration of the lung. This abscess was due to infection from the assailant's knife. The infection spread in the parenchyma of the lung eroding the blood-vessels, dissolving the catgut sutures, and permitted free, profuse hæmorrhage.

CASE V.—This patient died of a huge intra-pleural hæmorrhage. The intercostal vessels at the site of the stab wound had been ligated but bleeding occurred from the lung filling the entire pleural cavity; the blood became infected, and death occurred.

CASE VI.—This is an extremely interesting case in which the laceration of the chest-wall was situated an inch above the left nipple. The intercostal vessels were ligated and the laceration of the chest-wall was sutured. The patient became progressively worse and two days later died. An X-ray examination a few hours before death showed fluid in the pleural cavity. Post-mortem examination showed a laceration in the diaphragm one and one-half inches long through which the fundus of the stomach had protruded. The protruding portion became constricted and gangrenous, and ruptured, discharging its contents and necrotic wall into the pleural cavity. In this case, because of the high position of the point of entrance of the knife, an injury to the diaphragm was not suspected.

CASE VII.—In this case a bullet penetrated the lung and diaphragm, perforating the stomach in two places and the small intestine in four. The chest-wall, the diaphragm, and the gastro-intestinal lesions were sutured and post-mortem showed all the sutures quite competent, with the peritoneum clean and glistening. There was, however, a pneumothorax on the left side, pneumonia in both lungs, and complete collapse of the left lung. The factors leading to death were the pneumothorax with collapsed lung on one side, and compressed lung on the other, forming a favorable basis for the pneumonic process.

In the *third period* there were four deaths in thirty-two cases. In each case the lung was attached to the chest-wall according to the method to be described.

CASE I.—Death was due to sepsis. Blood culture showed a growth of hemolytic streptococcus. There was found at autopsy a purulent pleurisy, mediastinitis, and a massive collapse of the lung. It is of interest that the collapse did not occur on the injured side (where the lung had been sutured to the chest-wall) but in the opposite lung.

CASE II.—This patient was shot through the left chest. Ribs were shattered in front and in back and fragments of bone were imbedded in the lung. (Fig. 2.) A through-and-through channel caused by the bullet was seen in the lung. At each orifice the lung was sutured to the chest-wall. The patient was able to cope with the pleural and pulmonary injury but succumbed seven days later to a sepsis arising from a phlegmon in the chest-wall where fragments of bullet and bone had remained.

CASE III.—A bullet traveled from the right costal margin in the nipple line, lacerated the liver, tore the vascular border of the stomach and perforated the diaphragm and chest-wall. (Fig. 3.) The chest cavity was entered first, blood aspirated, the hole in the diaphragm closed and the lung attached to the chest-wall. Through a separate incision in the abdomen the bleeding gastric artery was ligated and bleeding from the liver controlled by packing. Death was due to peritonitis, general sepsis and pneumonia.

FIG. 2.

FIG. 3.

FIG. 2.—This patient had a through-and-through bullet wound of the chest. The lung and pleura remained clear of infection but a phlegmon of the chest-wall containing bone and bullet fragments (which may be seen just to the outside of the safety pin) was the seat of a sepsis to which the patient succumbed.

FIG. 3.—A bullet lacerated the right upper lobe. The shadow is due to intrapulmonary hæmorrhage. There is no shadow of fluid (blood) in the lower portion of the pleural cavity because the pleural cavity is obliterated by adhesions due to an empyæma thoracis which occurred thirteen years ago. This was demonstrated at operation.

CASE IV.—In this case there were penetrating stab wounds of both sides, but only the side of severer injury was operated upon because the patient was in poor condition. The patient died twelve hours after operation. We were unable to ascertain the exact cause of death.

Because all these deaths were cases of homicide they came under the jurisdiction of the medical examiner. Except for the last case all the post-mortem examinations were seen by us personally. A careful demonstration was made in each case by Doctor Norris, Doctor Gonzales, or Doctor Helpern. The teaching was invaluable.

Analysis of Complications and Causes of Death.—The essential factors causing death and complications of penetrating wounds of the chest may be classified as follows:

(1) Hæmorrhage from the lung, from the intercostal and from internal mammary arteries.

(2) Infection involving the chest-wall, the pleura and the lungs.

(3) Mechanical factors due to sucking wounds, pneumothorax, subcutaneous emphysema, and to the relaxation of the normally stabilized mediastinum.

(4) Visceral injuries involving the heart, lungs and diaphragm.

DEVELOPMENT OF THE NEW OPERATIVE PROCEDURE

Although our original object in operating upon each case during the second period was to ligate bleeding intercostal or internal mammary arteries, we discovered during our explorations other injuries and corrected them.

Thus in the case of Ethel A., a bleeding lung was encountered. (Figs. 4A and B.) It was sutured. We were mindful, however, of the case in which a sutured lung became infected and bled profusely at the place of suture. To avoid a repetition of this unfor-

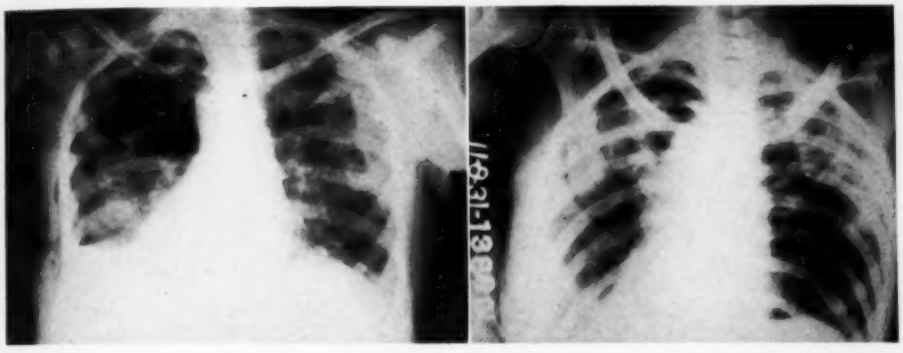

FIG. 4A. FIG. 4B.

FIG. 4A.—Case of Ethel A. This is a röntgenogram of the first case in which extrapleuralization and exteriorization of lacerated lung was performed. The film one day post-operative shows the left lung attached to the chest-wall at the place of suture with a pneumothorax above and a small amount of fluid in the costophrenic sinus. The extensive scars of tuberculosis are present.
FIG. 4B.—Case of Ethel A. Seven days post-operative. Pneumothorax and hemothorax have disappeared. The cavities of a chronic fibroid tuberculosis are present in both upper lobes.

tunate occurrence the lung was anchored to the chest-wall at the site of the exploratory incision. We contended that if the lung were to bleed externally, it could then be controlled by packing. After this was done we realized also that any possible purulent collection that might develop in the lung would empty through the hole in the chest-wall without contaminating the pleura. A post-operative X-ray picture in this case showed the lung attached to the chest-wall, partly aërated. Five days later the lung was completely expanded, and although there was diffuse bilateral pulmonary tuberculosis, the patient made an uneventful recovery.

The next case to be admitted was that of Leo B. (Figs. 5A and B.) His assailant perforated his chest-wall from the first to the fifth intercostal space, completely severing the cartilages of the second, third, and fourth ribs, causing a huge hemothorax and a through-and-through laceration of the lung which admitted three fingers. The patient was in marked collapse and several times during the operation he ceased to breathe and once his heart stopped. Each time a gentle, firm pull on the lung restored function. Small sections of cartilage were removed in order to allow for intrathoracic exploration.

Intercostal arteries were ligated. The lacerated portion of the lung was removed and a raw surface remained presenting an area about three and one-half long by one and one-half inches in width. Bleeding from this raw area was controlled by chain sutures. Since the restoration of respiration and of circulation was obtained during the operation by pulling upon the lung and thus stabilizing the mediastinum it occurred to us that permanent stabilization of the mediastinum might be obtained by fixing the lacerated lung in the wound of the thoracic wall by suture. This was accomplished by a continuous suture, interrupted at intervals. At the same time the lung when sutured into the wound acted as an excellent stopper and prevented sucking.

Thus in this case with a single operative procedure we were able to stabilize the mediastinum, care for the lacerated lung, take care of the sources of

FIG. 5A. FIG. 5B.

FIG. 5A.—Patient Leo B. The entire wound was produced by the assailant. The tissue in the centre of the wound is the lacerated lung which has been sutured into the wound.
FIG. 5B.—Patient Leo B. The wound is completely healed by scar tissue. There is no hernia of the lung.

hæmorrhage (the intercostal arteries and the lung), stopper the large hole in the chest-wall, prevent infection from entering the pleural cavity, and allow whatever infection might remain in the lacerated lung to be exuded.

The completeness of this operation in caring for so many important complications caused us to employ it in all cases except in one case in which a bilateral hemopneumothorax was produced by multiple ice-pick wounds. It is this operation of exteriorization of the lacerated lung which was performed upon all the cases, thirty-two in number, in the third period of our series.

The Operative Procedure.—(Figs. 6, 7 and 8).—The patient is brought

to the operating room by way of the X-ray room. Röntgenograms are made in each case except those which show marked constitutional collapse.

The anæsthesia of choice is avertin, 100 milligrams per kilo of body weight. Frequently it has been necessary to reënforce the anæsthesia with ether, preferably by the open cone and drop method. Early in our series we employed ether without avertin, or gas and oxygen without avertin, to which the patient, as a rule, responded poorly, thrashing about, vomiting, increasing the bleeding, and frequently aspirating vomitus. This was distressing to witness and then when the chest was opened there were violent excursions of the diaphragm and lung, and the mediastinal structures flapped irregularly and vigorously. With avertin, however, the lungs moved slowly and

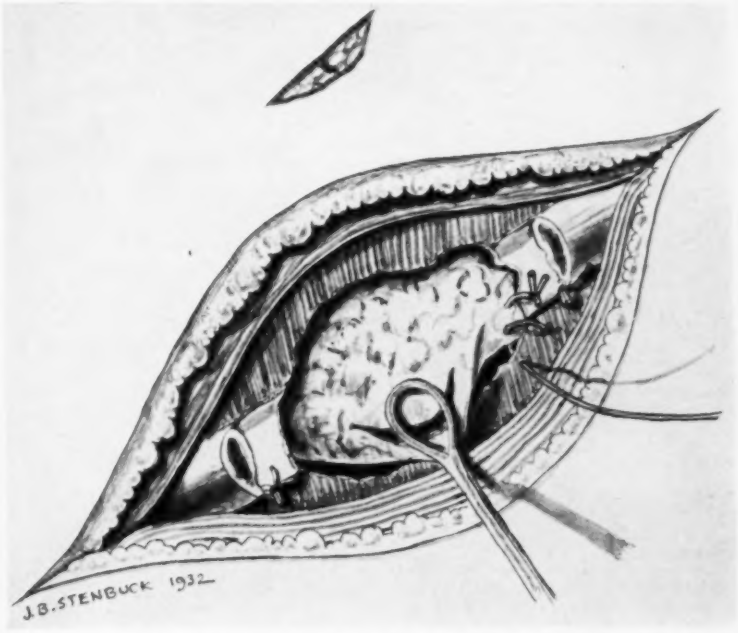

FIG. 6.—Operative procedure. The lung is grasped with a sponge forceps so that the lacerated portion is included. The lung is then sutured, beginning at the lower border, to the chest-wall. Note that the rib has been removed back far enough to allow for soft tissue to which the lung may be sutured. The skin wound of penetration is shown above the operative wound. It is not treated.

quietly and the heart was seldom disturbed. It was much easier for the patient and the surgeon.

While the patient is being anæsthetized physiological salt solution is introduced intravenously and 300 to 500 cubic centimetres are allowed to run in slowly. If the patient requires little in the way of operative procedure or if the wound is found to be non-penetrating, no further saline is given. When necessary, however, up to 3,000 cubic centimetres have been given on the operating table. Sometimes the saline is given merely as a preliminary to transfusion, which is given with citrated blood introduced into the infusion bottle after the saline. We have been fortunate in being able to secure blood

for transfusions whenever necessary and often so quickly that, with the coöperation of Dr. S. Weintraub and Doctor Nach, transfusions were given before the end of the operation.

The patient is placed upon the operating table with the wound uppermost. After preparation of the skin with tincture iodine and draping with sterile sheets, the wound is probed with a cotton applicator dipped in tincture iodine. In this way the direction and extent of the wound may be determined. The tract is not excised but an incision is made over the region where the pleura has been penetrated, which is usually an inch or more lower than the skin wound. The chest muscles, the pectorals or latissimus dorsi, are divided by blunt dissection if possible, and by sharp dissection if necessary in order to

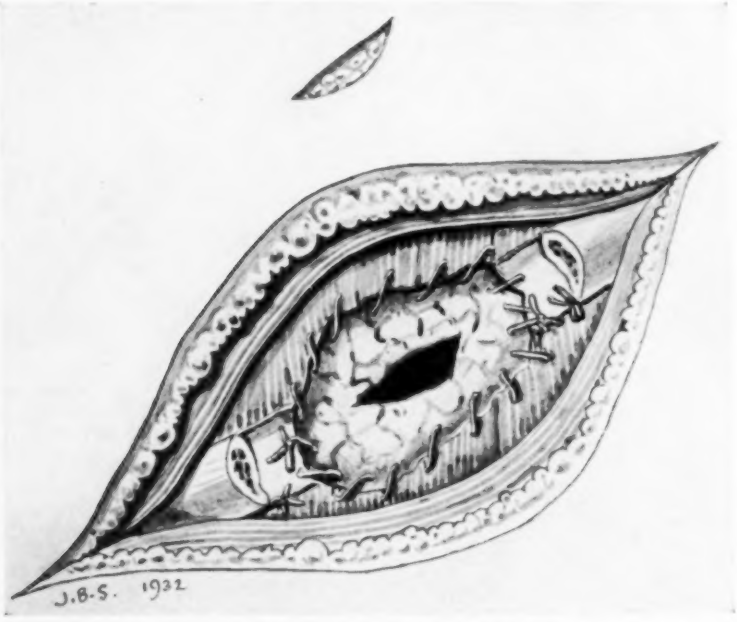

FIG. 7.—Operative procedure. The lung has been sutured to the chest-wall producing an air-tight closure of the pleural cavity and causing the wound in the lung to present externally. This is the operation of "extrapleuralization" and exteriorization of lung and laceration.

reach the hole in the pleura. About two or three inches of rib are removed subperiosteally. The rib selected is the one from which the intercostal muscle has been severed by knife or bullet. A rib denuded of the attached intercostal muscles cannot be employed later in the operation because we then require soft tissue to which to suture the lung. For the same reason the ends of the rib at the place of resection are rongeured so that no rib end overhangs the pleural orifice. In this way a ledge consisting of parietal pleura, periosteum, and muscle is formed.

The intercostal vessels are ligated on either side of the wound, which is then enlarged in order to permit exploration of the pleural cavity. Immediately upon entering the cavity the lung is grasped and held up to the chest-

wall in order to maintain mediastinal equilibrium and at no time during the operation is the lung allowed to recede to the mediastinum. Manipulating with sponge forceps, the lung is examined and if a laceration is found the lung is grasped so that the lacerated portion is held within the jaws of the forceps. Blood is aspirated if present in the pleural cavity, exploration is continued, and any further damage repaired. In case of diaphragmatic perforation, particularly by a bullet, a separate abdominal incision is necessary and should be made for exploration.

Lacerations of the lung vary in size and shape. There may be first, a simple penetration part way into the lung tissue, second, a through-and-through laceration, and third, a laceration starting at the border and running

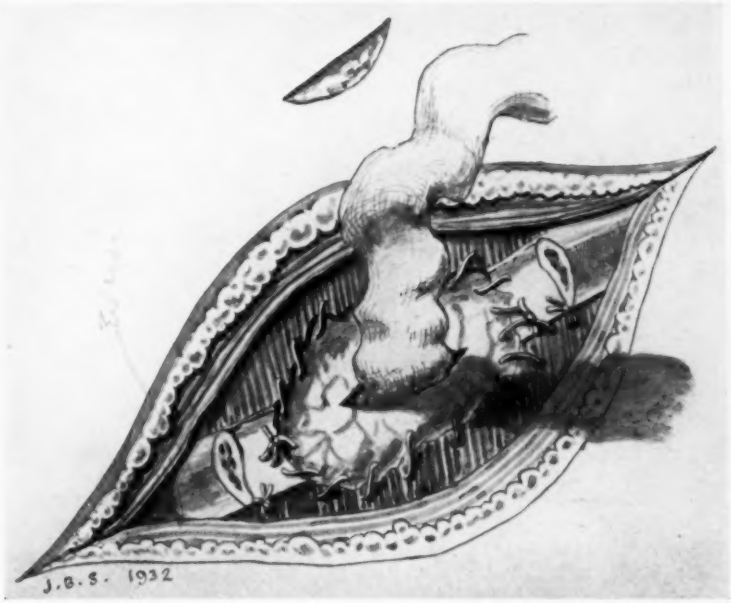

FIG. 8.—Operative procedure. Gauze is inserted loosely into the laceration and around the line of suture and the skin is sutured over it. Where there is no laceration in the lung it is nevertheless sutured to the chest-wall and gauze is placed along the line of suture.

toward the hilus, producing a V-shape laceration. In each case we have brought up the lung to the chest-wall in such a fashion that all the lacerated tissue is exteriorized and is extrapleuralized by means of suture. In the through-and-through lacerations they may be exteriorized as such, or, if necessary, may be converted into a V-form and thus may be more easily exteriorized.

The lung is held with a forceps so that the lacerated portion is in the centre of the hole in the chest-wall. The lung is then fixed to the chest-wall by a continuous suture (interrupted at either end). The lower edge of the orifice is sutured first because if the upper edge is first attached we usually find insufficient lung with which to work below because of retraction. Iodoformized gauze packing is inserted into the pulmonary laceration. We do

not close a laceration in the lung because of the great possibility of the development of infection. More gauze is packed around the suture line and beneath the chest muscles at the edge of the wounds. The skin and muscles are sutured tightly over the gauze packing, which is allowed to remain *in situ*, for four or five days.

Even when not lacerated, the lung is attached to the chest-wall, if the chest-wall has been penetrated. This obviates the bad effects of a pneumothorax particularly as regards the mediastinum and is a rapid way of closing the orifice in the chest-wall. Lilienthal, in his Thoracic Surgery, vol. ii, p. 548, reported a case in which by means of pneumopexy he successfully closed a large defect in the chest-wall. In no case have we seen a hernia of the lung follow the operation, although we have had lung to the extent of two and one-half inches in diameter present itself uncovered.

The Advantages of Exteriorization and Extrapleuralization of Lacerated Lung.—The advantages of our operative procedure may be summarized as follows:

(1) Blood and infectious material are allowed to drain from the lung away from the pleural cavity.

(2) The mediastinum cannot flap nor become displaced since it is held fixed by a steady pull through the lung which has been attached to the chest-wall.

(3) Pneumothorax is diminished in size.

(4) The lung is prevented from complete collapse and aërated because, being attached to the chest-wall, it must move with respiration.

(5) Subcutaneous emphysema is not produced because air from the lacerated lung can go only to the outside of the chest-wall.

(6) A tense pneumothorax cannot be produced for the same reason.

(7) Infection does not enter the pleural cavity from without because the pleural cavity is sealed off.

Although we have employed this procedure of attaching the lung to the chest-wall only in cases of penetrating wounds, we feel certain that its range of usefulness is much wider. From our observations patients in whom the lung was sutured to the chest-wall had an easier convalescence and lower death rate than those in whom it was not done. We presume, therefore, that in any type of case in which the chest-wall is opened (except, of course, in the presence of gross infection) the patient's chances of recovery are enhanced by the operation which we have described. It is preferable to insufflation of the lung just before closing the chest-wall. In those cases in which this was done our post-operative X-ray film frequently showed extensive pneumothorax although we thought the lung had been fully expanded before closure of the chest-wall.

In cases of combined intrathoracic and abdominal injuries with perforation of the diaphragm we have found it advisable always to enter the chest first in order to repair damage and gain the advantage of attaching the lung

to the chest-wall. The diaphragm can more easily be repaired from above and the patient can better bear the abdominal operation after the lung and mediastinum have been stabilized. If the abdomen is entered first, the hole in the diaphragm may allow air to enter the pleural cavity, thus allowing for an increased pneumothorax and increased compression of lung and consequent disturbance of the mediastinum.

Post-operative Treatment.—The patient, if extremely sick, is transferred immediately to an oxygen tent or preferably to the oxygen chamber, but if his condition is fair oxygen is employed by nasal cannula. Oxygen therapy has been applied with the close coöperation and the direction of Dr. J. G. M. Bullowa, of the Medical Service. We employ supportive treatment when necessary similar to that used in other surgical cases.

It is not necessary to re-insert packing into the lung after the first removal, indeed, in one case in which the lung was repacked possibly too firmly the suture line was broken in part and permitted infection of the pleural cavity from without, producing a purulent pleurisy. The patients remain in bed for a period of eight to ten days. The length of time varies, of course, with the condition of the patient. There have been no late sequelæ due to operation.

OUR PRESENT MANAGEMENT OF CASES OF PENETRATING WOUNDS OF THE CHEST

In our study we tried not only to perfect an operative procedure, but also to find, if possible, what cases required operation and what cases might be watched and treated for symptoms as they should arise. While we operated upon all cases during the second and third period of our observations, we realized fully that many cases may recover without operation. We have learned, however, that under certain circumstances, waiting may prove disastrous and therefore that operation is advisable, *viz.*:

(1) In cases of sucking wounds. The mechanical disturbance of lung and mediastinum should be corrected. If treated early with the operation of extrapleuralization of the lung, the sucking wound even if contaminated causes no disturbance, but if not so treated after the wound is infected the sucking cannot be controlled.

(2) In cases of wounds close to the sternal borders where the heart and the internal mammary vessels may be injured. The hæmorrhage from the mammary vessels is usually severe and may be rapidly fatal, for though they are anatomically extrapleural, practically they are intrapleural and as a rule bleed directly into the pleural cavity. Moreover, the tissues with which these vessels are in contact are not soft and yielding, but being fixed, permit only slight retraction and closure of the severed vessels. It must be remembered too, that when the artery or vein is cut bleeding may occur from either side because of the anastomosis.

(3) In cases in which the lung presents itself in the open wound. With

some respiratory exertion the lung may slip back into the pleural cavity even though on admission to the hospital it was fixed in the hole in the chest-wall. If it does slip back we are then presented with the problem of a sucking wound.

(4) In cases in which penetration might involve the diaphragm. Penetration of the diaphragm is not uncommon and may occur in wounds entering the chest anywhere below the fourth rib. On the right side no operative interference is necessary for repair of penetration of the diaphragm such as occurs in the average stab or bullet wound because the liver acts as a perfect stopper. On the left side, however, penetration of the chest and diaphragm carries with it the danger of perforation of stomach, intestines, and spleen and bleeding from mesenteric vessels. A perforation of the diaphragm may present no symptoms until late. When its existence is suspected operation should be undertaken immediately.

(5) In cases of tense pneumothorax. If on manometric reading there is positive pressure in the pleural cavity operation is advisable because it is not likely that the lesion which causes the tense pneumothorax will spontaneously subside. One may, however, temporize by removing air from time to time. We have found that for this purpose a pneumothorax apparatus is best since a measured amount of air may be removed, and a measured intrapleural pressure may be obtained.

(6) In cases of marked subcutaneous emphysema. Subcutaneous emphysema may spread to the neck and mediastinum producing marked difficulty in swallowing and in breathing. When these difficulties arise, the valve-like formation in the lung or chest-wall permits air to enter but not to leave the subcutaneous tissues with respirations. This may be corrected by exteriorizing the lung at the place of penetration in the chest wall.

If the injuries do not fall into one or more of these classifications at present we employ expectant treatment. If there is hemothorax or pneumothorax or both without any of the complications described above we depend mainly upon observations with the X-ray and with the pneumothorax apparatus. X-ray pictures are taken upon admission and again in five hours. This is an arbitrary period but we find it helpful. If there is increasing fluid, operation is performed. Otherwise the patient is observed further. If repeated pneumothorax readings show increasing positive pressure, operation is performed. While, as a rule, two days may be considered a safe period after which a hemothorax will not increase, a pneumothorax may become tense even as late as a week after injury. On this account intrapleural pressure readings should be taken at intervals for a week.

CARDIORRHAPHY IN WOUNDS OF THE HEART

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Previous to January 1, 1928, cardiorrhaphy had not been done at the Black Town Hospital at Baku, although the literature of surgery had already chronicled more than 600 cases. (Wagner; Mukhadze.)

We can now present three personal cases, two cases of stab wound, and a third case of gunshot wound. We have also made two exploratory pericardiotomies which failed to confirm a presumptive diagnosis of heart wound. Of these last cases one died on the operating table; the other recovered.

The characteristic symptoms of internal hæmorrhage were displayed by these patients: extreme pallor of skin, cold extremities and absence of pulse in peripheral vessels. In all three cases the operation demonstrated that a wound of the heart was the cause of the hæmorrhage. In the two last cases the pericardium was distended with blood. The first case was published in the monthly "Vestnik Hirurgii," vol. XIV, 1928.

Case I.—A student, aged twenty-four, was admitted to the surgical section January 7, 1928 (Fig. 1A), with a stab wound in the second intercostal space to the left of breast; he was pulseless. Resection of second, third and fourth left ribs and of a part of breast was done under local anaesthesia. Transpleural pericardiotomy was done by Mamikonoff. A stab wound was found in the wall of the right auricle. The wound was sutured with two sutures. A tight suture was applied to the pericardium. Fixation of the lung to costal pleura. Drainage of pleural cavity. Slow recovery. February 22, 1928, patient exhibited at Baku Surgical Society. March 8, 1928, left hospital.

Case II.—A man, aged twenty-eight, admitted August 22, 1931 (Fig. 1B), with stab wound on the left breast nipple; pulseless. Resection of fourth and fifth left ribs was done under ether narcosis. A great quantity of bloody fluid distended the pleural cavity. Transpleural pericardiotomy (Mamikonoff) revealed a stab cut of the left ventricle with profuse hæmorrhage from the wound. The heart wound was sutured. The pericardium was caught imperceptibly in the suture. Resection of pericardium. Additional sutures to bleeding heart wound. A tighly closing suture on pleura. August 23, bradicardia, dyspnœa, general condition very serious. Twenty hours after operation a repeated thoracotomy was done and 300 grams of blood extracted from the pleuro-pericardial cavity. Fixation of lung to the costal pleura. Again a tight suture on pleura. September 12 to 29 patient feverish. Puncture in the eighth intercostal space, left side below scapula; pus discharged, September 30, resection of eighth rib opened a limited abscess of pleural cavity. November 10 patient left hospital.

Case III.—Man, aged twenty-four, admitted September 16, 1923 (Fig. 1C), wounded two hours before admittance by an accidental shot. General condition very serious. Pallor of face and chilled extremities. Pulse on radial arteries appeared from time to time. A small bloody spot under left nipple. Transpleural pericardiotomy and cardiography was done under ether narcosis (Mamikonoff), through a cut twenty centimetres in length, running parallel to ribs at the left of breast. Resection of sixth and seventh ribs. The wounded pleura was distended with much blood; the pleuro-pericardial septum was greatly infiltrated with blood and had not the usual pulsation of heart. A transverse

pleuro-pericardiotomy gave vent to four large clots from the pericardial cavity, followed by a flood of bloody fluid. A wound, one cubic centimetre, half covered by a thrombus, was disclosed on the front wall of the right ventricle. Past the thrombus a thin flow of blood was escaping. The heart wound was rapidly sutured with a thick silk suture which cut through; second suture with the same result. The wound opening of heart, doubly enlarged, was controlled by the pressure of the hand of the operation nurse. A large piece of the pleuro-pericardial septum was cut out and the wound opening of the heart sutured with it with five sutures which controlled the hæmorrhage. By two additional side cuts the opening of the pleuro-pericardium septum was enlarged upward, and the heart carefully examined. No hæmorrhage. Pleuro-pericardial septum straightened and left unsutured. The lung fixed to costal pleura. A tight suture on pleura. Dressing. Physiological solution and digalen under skin; ice on wound.

Till September 20 pulse obscure, temperature high, dyspnœa. September 22, 750 grams of bloody fluid extracted from the cavity of left pleura. September 27, pulse irregular, rapid and uneven. October 2, *status idem*. Röntgen examination showed a

A B C

FIG. 1(A).—First patient operated on January 7, 1928. (B)—Second patient operated on August 22, 1931. (C)—Third patient operated on September 16, 1932.

great accumulation of fluid in the proper pericardial space, and displacement of heart to the right. Puncture of pericardium gave vent to 10 cubic centimetres of turbid fluid, admixed with broken-down tissue. Analysis of fluid proved the fluid as sterile. September 6, general condition much better. Fall of temperature. October 18, a control examination by röntgen-rays shows a dark aspect of the left lung apparently resulting from the thickening of pleura. Less fluid in the saccate pericardium space than during previous examination. Left half of diaphragm is by three fingers breadth higher than the right one, and does not absolutely exercise. The heart is 25 centimetres to the right from right sternal line. According to the röntgen plate, the bullet is lodged in the wall of the left ventricle.

October 23 the patient left hospital in satisfactory condition and healed wound, after being exhibited with the two previously operated patients at the conference of Baku Surgical Society, October 20, 1932 (Fig. 1).

According to literature data in nearly all cases of heart wounds operation has consisted (a few exceptions) in suturing of wound opening of the heart. But the effect of the operation is not the same in all cases. L. Rehn,[3] Fridrich

Hesse[1] and Constantini,[17] each having operated on six patients, lost one of them. J. J. Grekoff[19] has three cases of recovery out of six cases of cardiorrhaphy (last operation for a bullet embedded in the heart); while Bardenheuer does not succeed in saving one of his five patients, operated upon in connection with heart wounds, and Dshanelidse[2] loses four of his eight patients subjected to cardiorrhaphy. Muchadse[20] collected out of Russian literature thirty-two cases of operation on heart wounds performed at various points in the U. S. S. R. during the last ten years; in twelve cases death ensued. Such great difference in results of cardiorrhaphy cannot be assigned to the technics of operation exclusively, but to various conditions characterizing each individual case, *i.e.*, in other words, to numerous individual peculiarities of each case.

CHARACTERISTICS OF OUR PATIENTS

(1) Stab wound on the right auricle. Patient pulseless.
(2) Stab wound on the apex of heart (left ventricle). Patient pulseless.
(3) Blind gunshot wound on the right ventricle. Pulse appears at times.

Examining statistics and comparative data in the literature, we find the following:

According to Fisher, out of 452 cases of heart wounds not subjected to operation, twenty-two were gunshot wounds on the wall of right ventricle, fifty-nine stab wounds on the left ventricle and eleven stab wounds on the right auricle. These data are based on autopsy-confirmed material.

According to Dshanelidse, of 535 operated heart wounds, there were fourteen cases of gunshot wounds on the right ventricle, 167 stab wounds on the left ventricle, and thirty-seven stab wounds on the right auricle. One hundred forty-seven patients out of 491 had no pulse to be felt in peripheral vessels; Erich Hesse[1] cites forty-eight cases of heart wounds at Obukhoff Hospital, of which only four were gunshot wounds. There were fourteen cases of injuries of the right ventricle, twenty-six of the left ventricle and four of the right auricle. Fifteen patients had no pulse on peripheral vessels.

These data can, in some way, play a guiding rôle in the treatment of heart wounds by operation. It proves namely that the ventricles are more frequently subjected to operation; gunshot wounds bring patients to the operation table less frequently; stab wounds are more often met at the operation table, and the great bulk of patients appear on the operation table pulseless.

Early operative interference is an exceptionally important factor in cardiorrhaphy. In three cases of Erich Hesse's, where death ensued, operations were performed fourteen hours after wounding, *i.e.*, when patients were quite bloodless. In regard to this, Hesse declares, after studying heart wounds in forty-eight cases of cardiorrhaphy, that "only an early operation guarantees success." And, indeed, our patients have undergone operation six to two hours after wounding, *i.e.*, during a comparatively favorable period of time. Only the first patient, brought to the operation table six hours after wounding, quite bloodless, did not show any signs of life during three days following the

operation, and was lying as dead. Even his diuresis was limited to 30-140 grams of urine during these first three days. Therefore, it would seem that all wounded soldiers with heart injuries have to remain on the battlefield, if they are not subjected to an early operation. In connection with this Ballance[10] writes that numerous cases of hæmopericardium and extrapleural hæmorrhage perished on battlefields ere first aid could be administered. According to Ludwig Rehn's[3] data, based on German material from the World War, there were cases—and not unfrequent—when previous heart wounds were discovered during the secondary admittance of wounded soldiers to the hospital. This fact proves an exceptional tenacity of the heart as to wounds. Therefore, operations on heart wounds charge the surgeon with an immense responsibility for careful adherence to all cardiorrhaphy rules and, first of all, to the most elementary rule—irreproachable asepsis, breaking of which is up to date the cause of death in 50 per cent. of all cases. And, indeed, salvation of wounded depends on aseptic suturing of heart wound. Infection introduced during the wounding of the heart does not constitute a specific danger.

Prompt and careful stoppage of hæmorrhage is an important factor in technics of operative interference. In our third case suturing of the heart wound was met by exceptionally unfavorable anatomical conditions. The third of our patients was the youngest of the three, but his sutures cut through the muscular tissue of the heart. This usually happens with aged persons or those who indulge in alcohol. According to Erich Hesse's data, cutting through of sutures happened in eight cases out of forty-eight cardiorrhaphies. All except two of these eight patients died. Those two were saved by closing the heart wound with resected pieces of pericardium. In my case the heart wound was compressed, after cuttting through two sutures, by the hand of the operation nurse, while I cut out a piece of pericardium and succeeded in carrying out the last stage of the operation in my third case probably owing to *situs cordis superficialis* (according to Sauerbruch),[12, 13] which greatly facilitated transplantation of pericardium, performed without an assistant. It seems that later the edges of the transplanted piece of pericardium underwent partial necrosis, which was proved by analysis of fluid extracted from the pericardial space by means of puncture. It is necessary to emphasize a very important circumstance observed only with the third patient, namely, a partial covering of the wound opening of the heart by thrombus. A high thin flow of blood streamed past thrombus from the cavity of the right ventricle. All the operation personnel present at the operation were able to observe hæmorrhage direct from the exposed heart. As to the heart activity during the suturing, it is necessary to mark that we were unable to distinguish movements of systole from diastole in all our three cases. Assertions by some of the necessity to suture heart wounds during systole, and of others during diastole, are probably either results of experimental observations on animals, or theoretical reasonings, resulting from the fancy of surgeons, who suffered a severe nervous strain during performance of cardiorrhaphy. Pleura and pericardium drainage question is settled each time individually.

E. Hesse,[1] Grekoff,[19] Zavialoff, Bländ-Sutton, Müller and many others prefer tight suturing of pleura and pericardium. According to the literature data of Dshanelidse, both serous bags were sutured tightly in 145 cases: recovery in eighty-five cases, while of eighty-five cases treated by drainage of pleura and pericardium, there were only forty-one cases of recovery.

Our first patient was subjected to operation with tight suturing of pericardium and drainage of pleural cavity. But the other two patients were operated on with tight suturing of costal pleura, and in both cases a wide connection was left between pleura and pericardium cavities; in the second case, as in the third, pleura pericardium septum was not sutured at all for fear to compress the heart in the reduced pericardium bag. In all our three cases of transpleural pericardiotomy the lung was fixed by sutures to costal pleura.

In our second case we were forced to open the pleura twice after cardiorrhaphy: the first time twenty hours after the cardiorrhaphy to evacuate the bloody fluid from pleuro-pericardial cavity; second time, thirty-five days later, to empty a limited pus exudation of the pleural cavity. In our third case we were obliged to empty in turn both serous cavities by puncture. My three cases confirm the superiority of tight suture, which corresponds to literature data. Besides other advantages, a tight suture gives patients a possibility to avoid frequent dressings and consequently lessens the danger of reinfecting serous cavities. According to Jehn's data, resulting from observations during the World War, a tight suture on the pleura led to 90 per cent. cases of recovery, while conservative treatment of injured pleura (pneumothorax) led to death in 90 per cent. of all cases. The latter method was applied by German surgeons at the beginning of the World War. (Jehn.)

In all three cases of transpleural pericardiotomy performed without an apparatus for increased lung pressure, we had dislocations of thoracic organs, namely, displacement of mediastine, a partial lung collapse and dislocation upward of the left half of diaphragm immediately after the operation. Traces of this pathology in the topography of the thoracic organs still persisted when the patients left hospital. Even now the left half of the diaphragm of all three cardiorrhaphied patients is higher than the right one and does not move in excursion.

Basing on the two last cases, where integrity of pleuro-pericardium septum was not restored, we may conclude that the even connection between pleural and pericardial cavities may not have serious consequences, provided a hermetic closing of thorax and fixation of lung to costal pleura is carried out.

Some words about foreign bodies embedded in the heart: location of the bullet in the walls of the heart was not my task while suturing the heart wound in the third case. L. Rehn considers that only those foreign bodies in the heart which move freely in its cavities must be subjected to extraction. Such alien bodies can penetrate into the aorta or pulmonary artery and provoke most serious complications. Borst cites two such cases. In one of them a bullet caused aneurism of pulmonary artery, and injury of aorta with formation of fistula between both vessels and death. Klose[4, 5] notes from the literature seven cases of bullets and fragments passing from the heart cavity into

the aorta and pulmonary artery, in four of which death ensued. Foreign bodies which are fixed to the endocardium are not subjected to extraction, provided there are no special symptoms. Such fixed foreign bodies are usually covered by interstitial membrane and do no harm later.

In one case (J. Hiss) a shell fragment passed through the left ventricle and embedded itself in the wall of the right ventricle. As a result pericarditis, endocarditis, an insufficiency of the bicuspid valve; recovery. Müller was forced to operative interference in connection with heart compression, as blood streamed into the pericardial cavity. During the operation, performed three hours after wounding, it was found that the heart wound did not bleed any more. A bullet, lodged in the front wall of the right ventricle, was not extracted; recovery. J. J. Grekoff explained his operation; ventriculotomia explorativa cordis, by the fear that a bullet could pass into the pulmonary artery. This hypothesis was caused by rotating movements of the bullet in the right ventricle cavity as röntgen examination proved. At examination of our third patient November 21, 1930, a keen systolic murmur could be heard at the apex; pulse was 126 a minute. By the time the patient left the hospital all these abnormal phenomenona had disappeared, giving place to a healthy physiological heart activity. In all our three cases of operative exposure of the heart we applied the method of final rib resection, that greatly simplified later on our task of pericardium puncture to which our last patient was subjected November 2.

In spite of the seriousness of heart wounds and of the numerous unfavorable conditions usually accompanying such wounds, all our patients (except the third) are at present doing their work. The last patient, though not bedridden, is still an invalid.

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JEJUNOSTOMY

A CLINICAL AND EXPERIMENTAL STUDY OF THE TECHNIC OF THE OPERATION *

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Jejunostomy is generally agreed to be a useful procedure although its indications are not generally accepted. On the Third Surgical Division, Bellevue Hospital, it has been a practice to perform jejunostomy in certain inoperable ulcers and growths of the stomach and in a small percentage of acute inflammatory conditions of the abdomen in which the normal intestinal peristalsis is seriously disturbed. In the course of this work, certain apparently inexplicable instances of mortality have occurred. In the considerations of these fatalities,[1] it did not seem that the operative procedure was misapplied nor did the theories on the cause of death appear satisfactory. Hence this attempt has been made to supplement the clinical observations by further examinations under experimental conditions with the hope of presenting the most probable causes of human failure after jejunostomy.

Jejunostomy may be looked upon as temporary and requiring the use of a tube, or permanent and not requiring a tube.

The method most frequently employed in this series covering the past thirteen years, or from 1920 to 1932, has been the (tube) method of Witzel. The operation, almost always an emergency, has been carried out in one stage. A soft rubber catheter, 18 to 25 F., is introduced within a loop of jejunum, 20 to 30 centimetres from the duodeno-jejunal flexure, through a small cautery stab or incision. The tip of the catheter is sutured to the margin of the intestinal wound with fine chromic gut and inverted with a purse-string of the same material. The tube is directed caudad while the next remaining 5 centimetres is laid against the antimesenteric wall of the intestinal loop and inverted with continuous or interrupted Lembert sutures. This stomatized loop is then sutured to the peritoneum and fascia of the abdominal wound and the wound is closed about the tube.

From an examination of the table of the hospital cases (Table I) it is evident that eleven of the twenty lived two weeks or more (possibly as long as the life expectancy in extremely advanced gastric malignancies), and that nine died within two weeks. The records of the early cases did not disclose the pathology of the stomatized loop, the duodenum, omental fat, or peritoneum. Obstructive symptoms, excoriation, and catheter troubles are commented upon. The elimination of the tube, even for a few hours, may have relieved a few of these patients from duodenal obstruction. On the other

* Read before the New York Surgical Society, October 12, 1932.

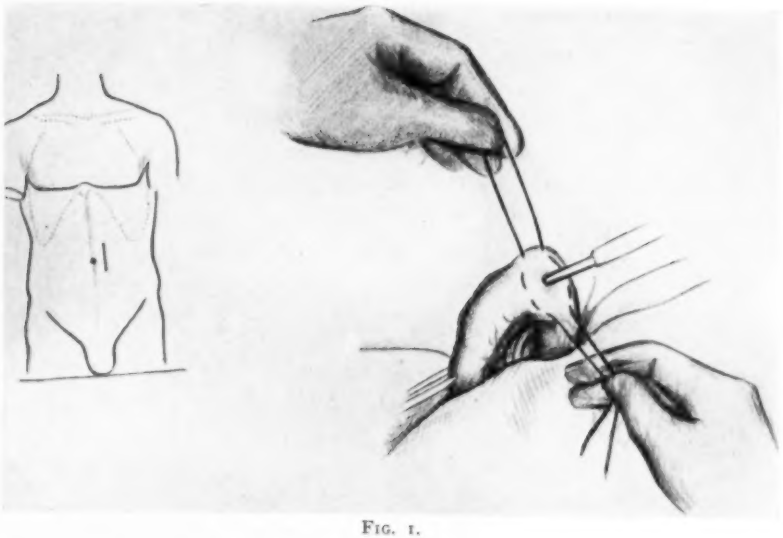

FIG. 1.

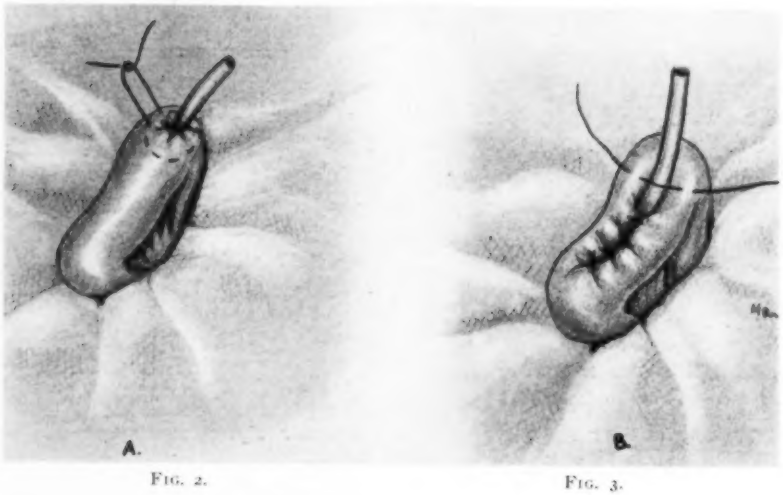

FIG. 2.

FIG. 3.

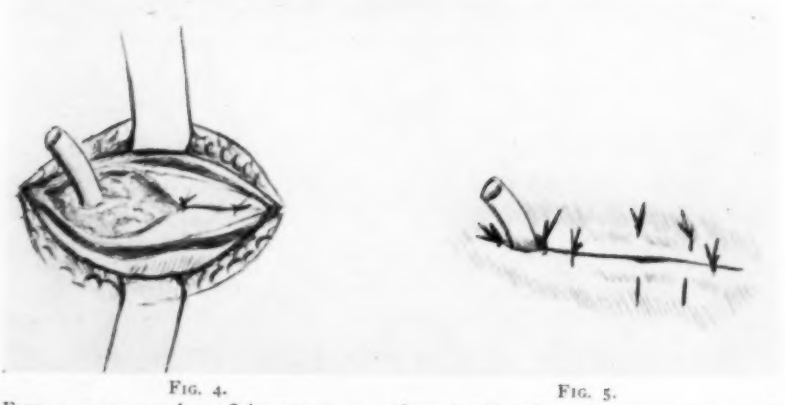

FIG. 4.

FIG. 5.

FIGS. 1, 2, 3, 4 and 5.—Jejunostomy as performed with tube and omentum interposed. Omentum was not mobilized about tube in the hospital series.

hand, if the tube is to be easily replaced, it seems necessary to replace it at once. With few exceptions the technic was that described above.

The author has repeatedly used omentum as a buffer against leakage about the catheter within the peritoneum as is done in ileostomy with success without realizing its dangers until observations had been made in the experimental series. (See Tables II and III.)

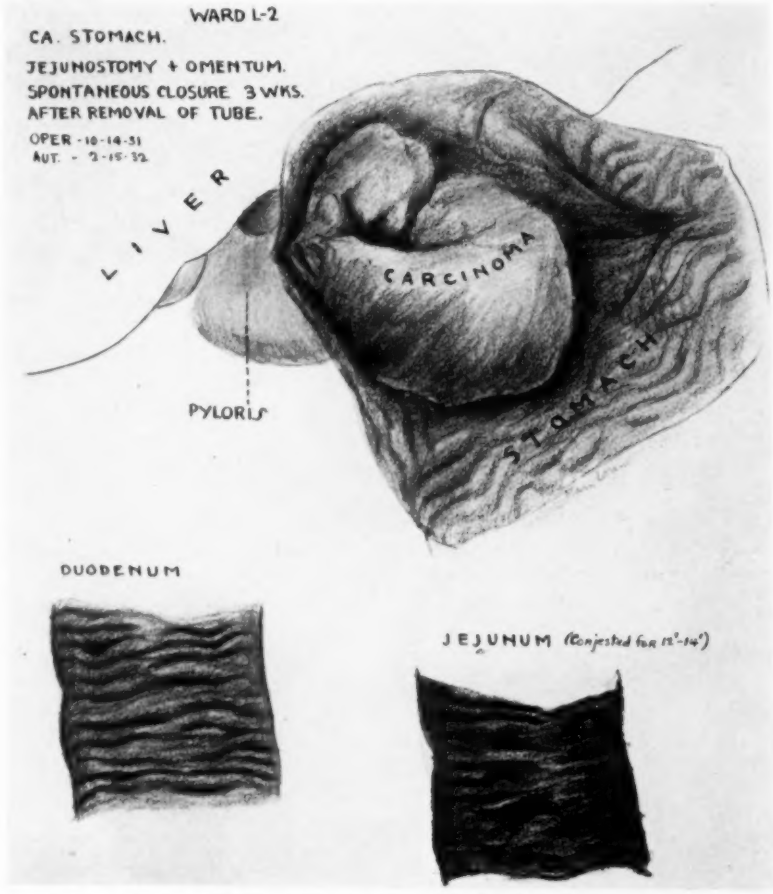

FIG. 6.—L. C. (See Table I.) Necropsy findings in clinical jejunostomy (with omental grafting) for inoperable carcinoma of stomach. Lived fairly comfortably four months. Jejunostomy closed spontaneously after passage of tube. Note especially the hæmorrhagic jejunum and normal-appearing duodenum. This jejunitis was thought due to irritation from feedings, disturbed secretions, and trauma from catheter.

Extract from post-mortem report, L. C., February 15, 1932.—The duodenum appears natural except for a moderate amount of congestion of the mucosa. The papilla of Vater appears natural. About 1 foot from the fossa of Treitz the mucosa of the jejunum is markedly hæmorrhagic. At this point the jejunum is adherent by a rather firm band of adhesions to the anterior abdominal wall at the site of the incision. This hæmorrhagic area extends the entire extent of the jejunum and the first part of the ileum. This section of the bowel contains a watery red-colored fluid. In the remainder of the ileum the mucosa appears natural.

These experiments have been performed upon dogs carefully prepared and anæsthetized with morphine and sodium amytal. Operations were carried out upon electrically heated tables. Fluids were administered by hypodermoclyses, by jejunostomy, and by mouth. It was not practicable to collect

TABLE I

Temporary Jejunostomies as Performed in Bellevue Hospital (3d Surg. Div.) Series, 1920–1932, Including Inoperable Carcinomata of Stomach

Case No.	Post-operative Das.	Technic	Unfavorable Post-operative Findings
V. 1, 22	60	Witzel; peritoneal fixation	Diarrhœa
V. 1, 31	7	Witzel; peritoneal fixation; drain	Leakage
V. 1, 32	15	Witzel; peritoneal fixation; drain	Distension; difficulty in retaining tube
V. 1, 33	14	Witzel; peritoneal fixation	?
V. 2, 81	43	Witzel; peritoneal fixation	None reported
V. 2, 103	0	Witzel; peritoneal fixation	Died same day
V. 2, 104	23	Jejunostomy	Distension
V. 2, 106	25	Jejunostomy	?
V. 2, 119	1	Witzel	Intestinal obstruction (?)
V. 3, 120	15	Witzel	Difficulty in retaining tube; leakage
V. 3, 125	12	Witzel; peritoneal fixation	Difficulty in retaining tube; leakage
V. 3, 127	7	Witzel	Difficulty in retaining tube
V. 3, 131	63	Jejunostomy; peritoneal fixation	Leakage
V. 4, 177	9	Witzel; omental interposition	Intestinal obstruction
V. 4, 192	1	Witzel	Intestinal obstruction (?)
S. S.	20	Stamm-Kader; muscle-peritoneal graft	Difficulty in retaining tube
F. C.	2	Witzel; peritoneal fixation	?
L. C.	120	Witzel; omental interposition	Difficulty in retaining tube
L. J.	30	Witzel; peritoneal fixation	?
F. C.	2	Witzel; peritoneal fixation	Intestinal obstruction

TABLE II

Experimental Table Showing Effects of Omental Interposition in the Witzel and Stamm-Kader Technics

Experiment Number	Duration in Das.	Technic	Findings †
J. 1	2	S–K	Leakage. Omentum suppurative. Peritonitis. Mic.: duodenal erosions, cellular infiltration
J. 2	2	W	Obstruction. Duodenum dilated. Jejunum congested, especially invaginated wall. Mic.: duodenal erosions, infiltration. Jejunal capillary dilatation of mucosa. (See drawing.)
J. 3	10	W	Obstruction and peritonitis. Leakage. Duodenum dilated, eroded, congested. Jejunum congested, especially invaginated wall. Omentum hæmorrhagic, suppurative. (See drawings.)
J. 4	6	W	Leakage. Adhesions incomplete. Peritonitis. Omentum suppurative. Obstruction. Duodenum and jejunum congested, especially invaginated wall. (*Cf.* drawing.)

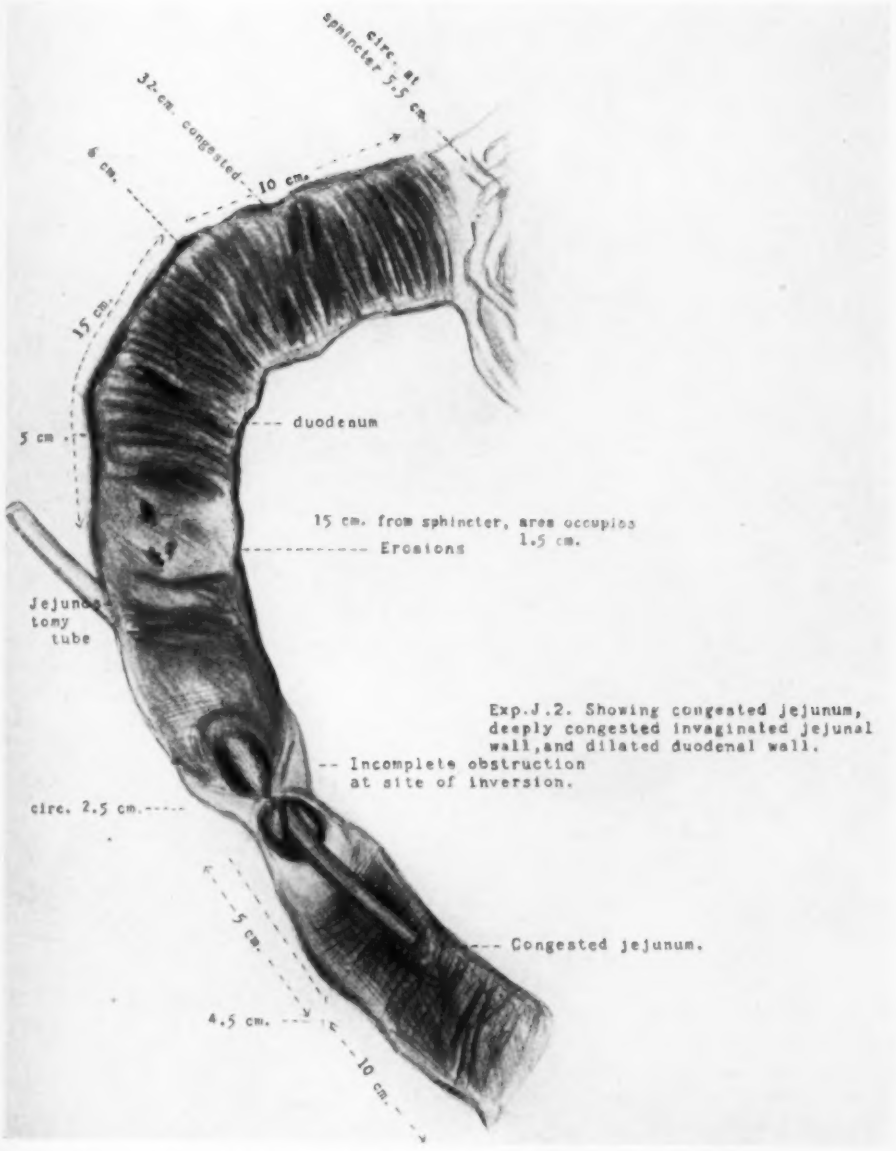

FIG. 7.—J–2. (See Table II.) Early obstructive changes following jejunostomy.

FIGS. 7, 8, 9, 10, 11 and 12.—Drawings illustrating experimental jejunostomy with tube and superimposed omentum as carried out in a few selected hospital cases. For convenience, the purse-string principle is referred to as "Stamm-Kader" or "S-K" and the invagination of the tube as "Witzel" or "W."

TABLE III

*Experimental Table Showing Omental Factor and Influence of Gastrojejunostomy upon External Jejunostomy**

Experiment Number	Duration in Das.	Technic	Findings †
J. 5	6	No Omentum GE W.	Adhesions firm. Obstruction slight. Duodenum and jejunum normal
J. 6	3	Omentum GE S–K	Leakage. Peritonitis. Adhesions incomplete
J. 7	5	Omentum GE S–k	Leakage. Peritonitis. Adhesions incomplete

TABLE IV

Experimental Table Showing Results of Peritoneal Coaptation in Jejunostomy

Experiment Number	Duration of Experiment Das.	Technic	Findings
J. 9	?	S–K	Adhesions firm; omentum, duodenum, jejunum normal. Invaginated jejunum wall congested. (v. drawing.)
J. 10	2	Witzel	Adhesions firm; incomplete obstruction; invaginated jejunum wall necrotic. (v. drawing.) (Mic.: Necrosis at sutures; jejunum congested, superficially necrotic and infiltrated)
J. 11	2	Witzel	Peritonitis and obstruction
J. 20	2	Witzel (no tube)	Gas infection of wound
J. 21	19	Autolytic Stitch	Adhesions firm; stoma clean-cut; No inflammation

* *Cf.* drawings of J.4 and J.5.

† Attention is called to microscopical changes observed in duodenal and jejunal loops after jejunostomy. These changes, it will be noted, correspond with those already reported after simple obstruction by Hartwell, Hoguet, and Beekman (Arch. Int. Med., vol. xiii, p. 701, 1914). Superficial cellular necrosis, erosions, and leucytic infiltrations predominate in the duodenal loops and, vascular congestion, although present in the oral loops, is almost invariably present to some degree in the jejunal loops. This congestion centres about the jejunal stoma and diminishes caudad but involves the adjacent two feet of the intestinal mucosa. Autopsied human specimens indicate more extensive involvement in long-standing cases that have gone without careful medical (dietetic) supervision. The thromboses and gangrene, described by Van Beuren (ANNALS OF SURGERY, vol. lxxii, p. 610, 1930) do not apply excepting in respect to the invaginated jejunal wall in certain instances after the Witzel technic which shows necrosis from terminal vascular occlusion. These findings harmonize with the gross appearance of the tissues.

and administer the gastroduodenal secretions during the first two post-operative days and introduce them with the feedings as the author has done in the human cases, but the helpfulness of these digestive juices in the jejunal loop is indicated by the tissues of the dog jejunostomized after gastrojejunostomy. (See Table III, Experiment J.5.) Blood chemistries were carried out in five of the animals before and after operations. Greenwald, who very kindly made these determinations, reports a tendency in all of the animals toward

FIG. 8.—J–3. (See Table III.) Omentum acutely inflamed. Invaginated jejunal wall deeply congested. Adhesions not sufficient to protect peritoneum.

nitrogen retention similar to that of the duodenally obstructed animals. The operative technics have been modified in the successive animals to meet the indications disclosed by the respective autopsies. The first four were operated by the Witzel method with the exception that omentum was left between the stomatized loop and the parietal peritoneum. This method was compared with a modified Stamm-Kader technic with interposed omentum and both technics were compared without omentum. Finally, the method was evolved

which appeared to meet the indications of intraperitoneal leakage and peritonitis. (See Tables IV and V.)

It is necessary at this point to digress in order that one may be prepared for the difference in the productive inflammation about the jejunostomy tube in those instances in which peritoneal surfaces are brought directly in con-

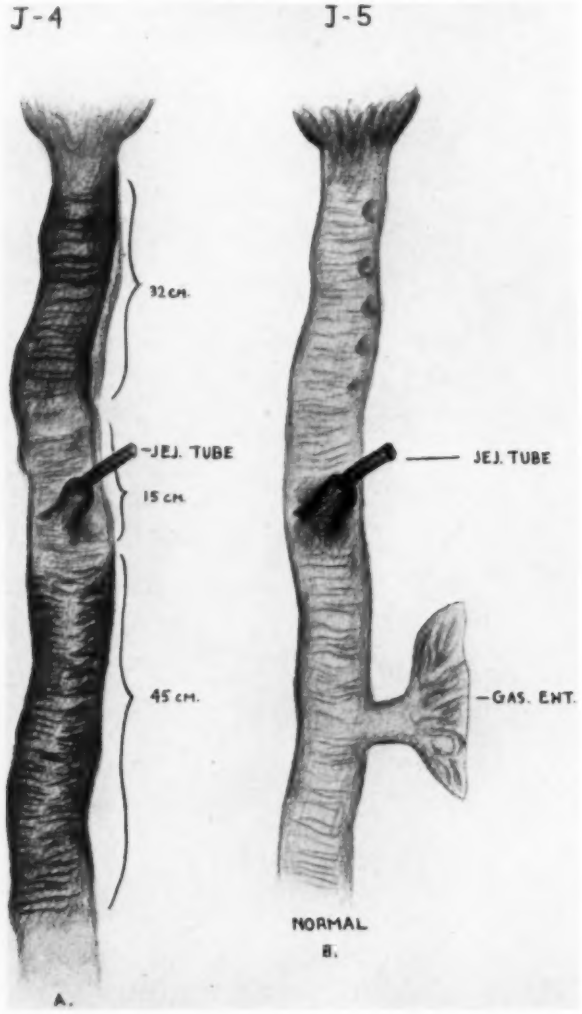

FIG. 9.—J-4. (See Table II.) Duodenitis and jejunitis and peritonitis following jejunostomy and omental grafting. Mucosal changes essentially due to obstruction at tube site. J-5. (Table III.) Normal duodenum and jejunum following technic similar to J-4, but with gastroenterostomy added.

tact, and in those in which omentum is left between the visceral and parietal peritoneum. It has been repeatedly found that the adhesions between the peritoneal surfaces are more firm and better organized, while those between omentum and peritoneum are less firm and at one site about the tube deficient. This deficiency inevitably allows enteric contamination of the adjacent omen-

tal and visceral surfaces and leads to acute peritonitis. The fat of the omenta or falciform ligament takes on a bright red color, much more pronounced than the smoky red injections of the serosal surfaces. In a few cases fat necrosis, as observed in pancreatitis, was observed. The inference naturally follows that the peritoneum is more resistant than fat to the seeping fluid from the jejunum.

These findings are believed to be in accordance with clinical experience after the method of jejunostomy outlined above for the hospital series. Co-Tui has shown that the trypsin content of the small intestine varies inversely with the distance from the pylorus, and that the amount in the oral jejunum is many times that in the terminal ileum. Furthermore, in apposing living

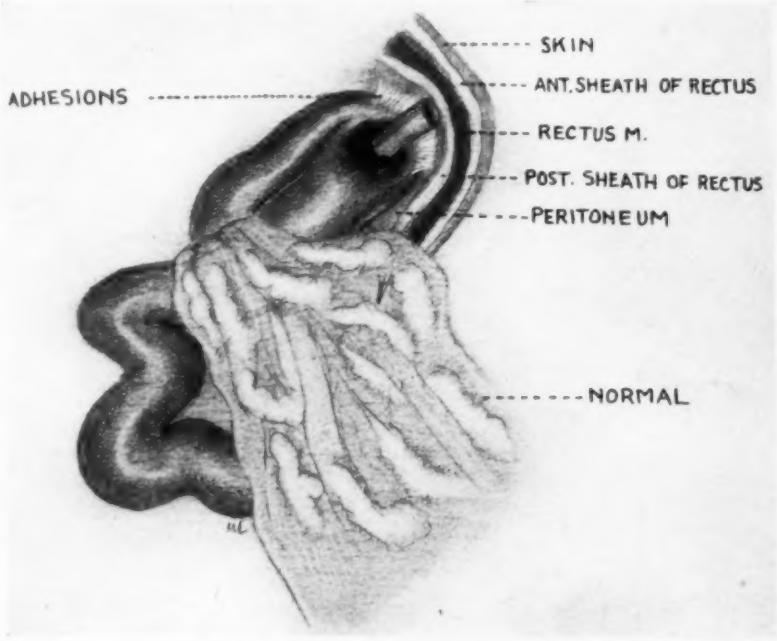

FIG. 10.—J-9. (See Table IV.) "S-K" technic with peritoneal coaptation. Note adhesions (firm) and normal viscera. Congested inverted wall only. Pathological finding due to operation.

tissue to inert rubber tubing it is evidently impossible to produce or to maintain a water-tight or leakage-proof connection so that "seepage" of trypsin-containing material is inevitable. During the first few hours, if organization of the exudate about the tube within the peritoneum can proceed, peritonitis will have been averted and leakage will be carried out on to the abdomen. In one instance the leaking fluid attacked the subcutaneous fat and produced necrosis in this layer well out upon the chest and abdomen. (See Table IV, No. J.20.) This experience suggests the precaution of protecting the subcutaneous fat with sutures, perhaps by suturing skin to fascia, in closing the abdominal wall or of leaving the stomatized loop or loop-catheter long and anchored a distance from the wound. Although the omentum has been used

in jejunostomy as it is commonly used in ileostomy, experimental observations seem to indicate that the stoma about the indwelling catheter should be carefully peritonealized first before attempting to "tuck" the omentum about the suture line.[2]

The accompanying experimental tables and illustrations indicate the presence of firm adhesive strands in the "peritoneal coaptation" series and the loose, ineffective adhesions in the "omental" series.

Attention is called to the tendency to the production of acute obstruction during the first two post-operative days because of the swelling, œdema of the jejunal wall at site of the catheter, and local spasm. It is necessary that as small as practicable a catheter should be chosen.[3] As a more effectual provision against tissue damage and obstructive symptoms, it is suggested that a Levine tube be placed within the stomach and fluid frequently aspirated

TABLE V

Experimental Table Showing Results with Muscle-peritoneal Graft

Experiment Number	Duration in Das.	Technic	Findings
J. 22	9	S–K	Jejunum natural
J. 23	3	S–K	Adhesions incomplete; peritonitis
J. 24	6	S–K Omentum	Adhesions firm; necrosis about tube. (*Cf.* drawing.)
J. 25	10	W (Tube removed)	Adhesions firm; stoma natural; graft viable
J 26	2	W (c. Interrupted sutures) Omentum	Adhesions firm; invaginated wall congested
J. 27	2	W Omentum	Adhesions firm; invaginated wall congested. (v. Drawing and Microphotograph.)
J. 45	3	S–K	Adhesions incomplete at upper angle not covered by graft where "seepage" occurred. Flap viable

during the first forty-eight hours from the time of reaction from operation, and that such fluid be refrigerated until jejunal feeding. It may then be brought to the proper temperature, mixed with each feeding, and passed into the jejunum. The elaborate preparations of jejunal feedings, as advocated by Ivy, are believed unnecessary if the simple precautions of "naturalizing" the jejunal ingesta outlined above be carried out. The findings after jejunostomies combined with gastroenterostomies emphasize the increased toleration of the jejunum to predigested nutriment when mixed with secretions from the upper reaches of the digestive tract.

If the Witzel technic is employed, as indicated in the accompanying illustrations, some precautions must be taken to safeguard the integrity of the invaginated jejunal wall. The portion invaginated is, of course, antimesenteric and supplied by terminal vessels. Continuous Lembert suturing ligates these end-vessels. Interrupted sutures are not sufficient to prevent deep congestion due to the bending in of this one to two inches of wall. After this

operation, it is recommended that the jejunostomy tube be removed daily, cleaned, and replaced at once. If the tip of the catheter be promptly placed at the entrance of the fistula its re-introduction may be less difficult. This

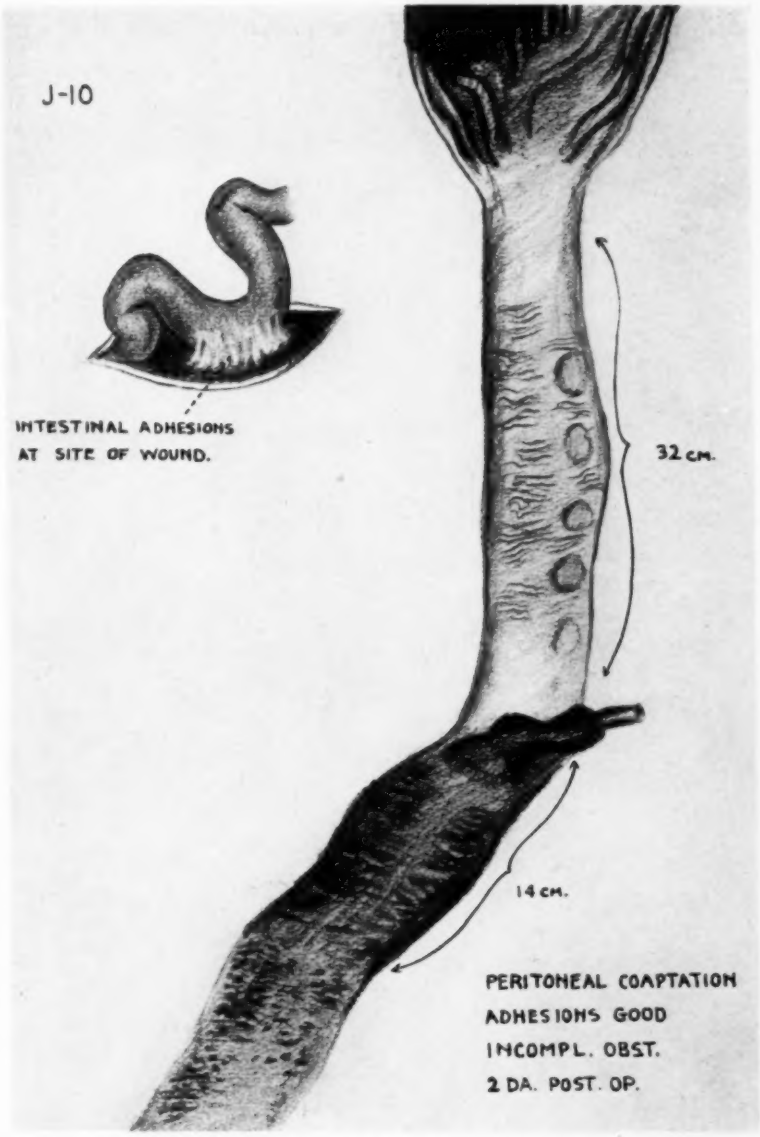

FIG. 11.—J–10. (See Table IV.) Drawing showing ample adhesions (insert) and hæmorrhagic invaginated jejunal wall. Obstruction and necrosis followed.

will allow some time for readjustment of the local circulation within the invaginated wall, the preservation of which protects both peritoneum and skin from leaking intestinal contents.

The utilization of a modified Stamm-Kader technic would seem to sim-

plify the immediate after-care of the fistulous tract and diminish the dangers from necrosis of the invaginated intestinal wall.

It is believed that two factors to be desired in a good jejunostomy are keeping the stomatized loop close to the abdominal wall and keeping the omenta "within call" of the jejunostomy site. It is thought that one virtue

FIG. 12.—J–21. (See Table IV.) Normal viscera and peritoneum following jejunostomy by autolytic stitch and direct peritoneal fixation.

from a *suspended* rather than a *fixed* jejunum and from closely applied omentum is spontaneous closing of the stoma (as is desired in acute cases). This has been observed in the author's few clinical cases. The modification to be suggested, whether new or old, has evolved itself from this series of observations and seems best to meet the indications thus far.

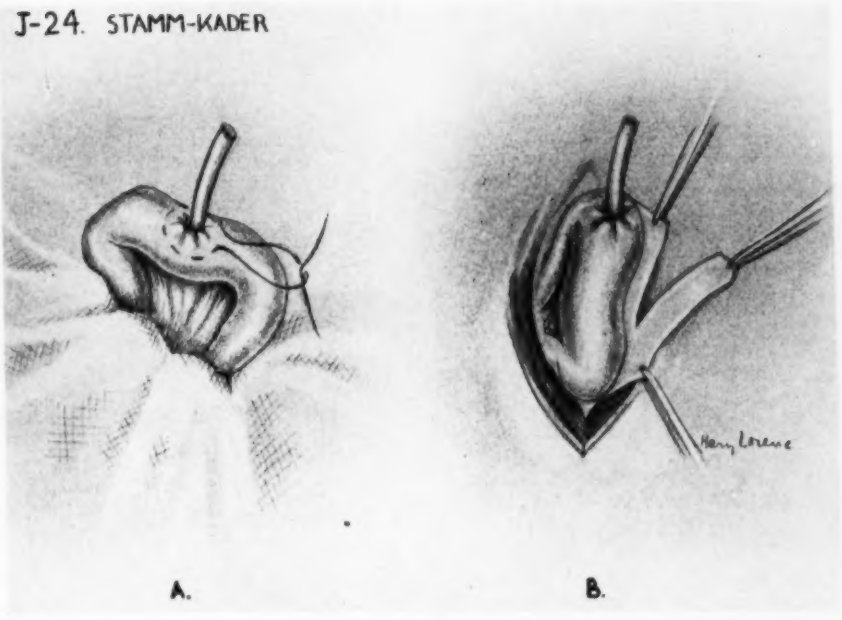

FIG. 13.

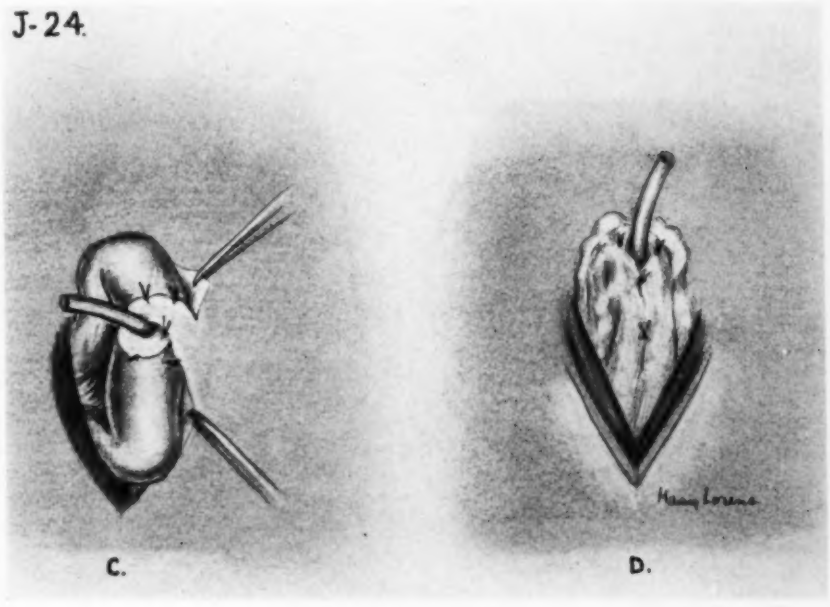

FIG. 14.

FIGS. 13 AND 14.—(See Table V.) Jejunostomy with author's suggestion of muscle-peritoneal flap taken from edge of operative wound to provide suspension of jejunal loop and peritoneal coaptation. Tube is inverted—not invaginated as in J–26 and J–27.

This procedure, as appears in the accompanying drawings, comprises an attached muscle-peritoneal flap slit off from the lateral edge of the abdominal wound and of sufficient size and shape to adequately cover the line of suture in the Witzel or the circumference of the tube in the Stamm-Kader method.

FIG. 15.—J–22. (See Table V.) Specimen showing normal findings following above technic.

This flap is sutured with interrupted Lembert sutures to the jejunal wall. Over this transplant is laid the edge of the great omentum. The wound is thereafter closed in layers with interrupted sutures about the tube. The loop remains suspended by the wound flap. The flap is nourished through its

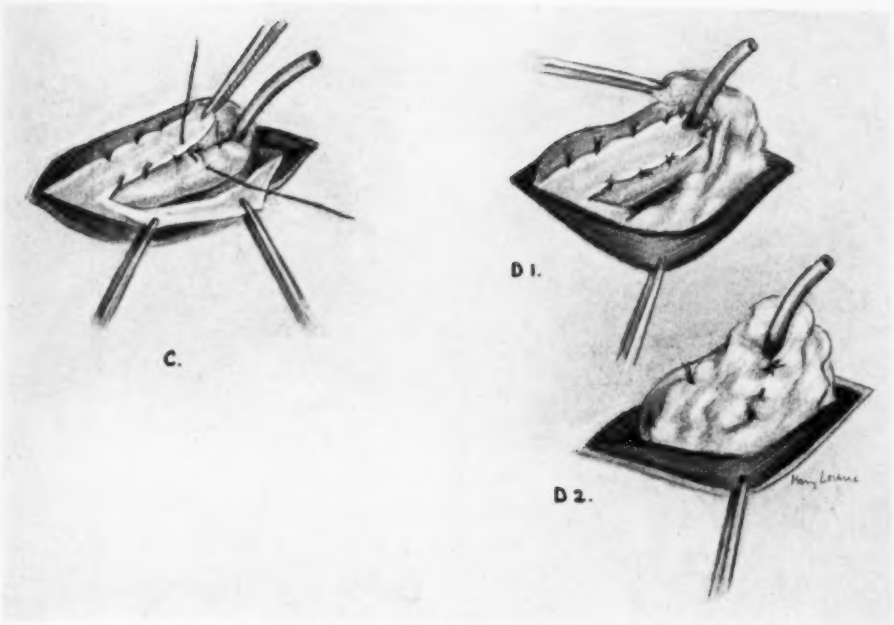

FIG. 16.—J–26. (See Table V.) "W"-jejunostomy with author's suggestion of muscle-peritoneal flap taken from edge of operative wound to provide peritoneal coaptation and suspension (rather than fixation) of jejunum.

FIG. 17.—J–27. (See Table V.) Same principle as above in J–26 showing objection of invagination of wall still remains. Invaginated wall about tube is deeply congested and may necrose.

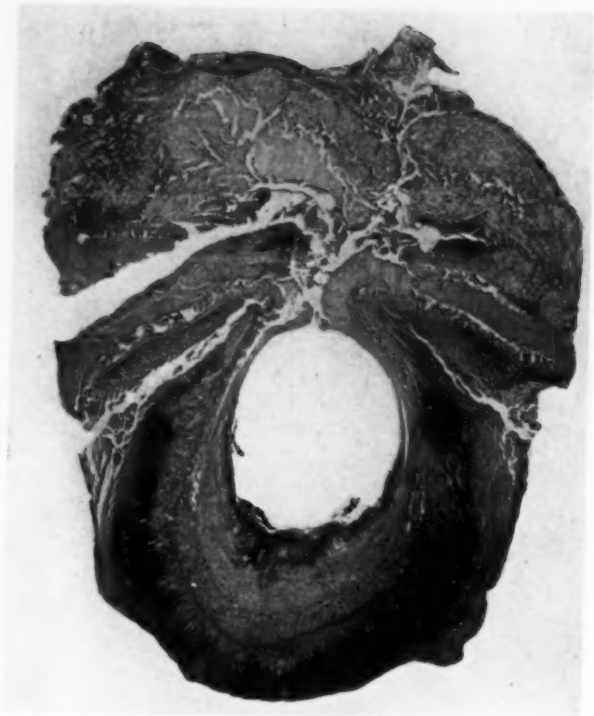

FIG. 18.

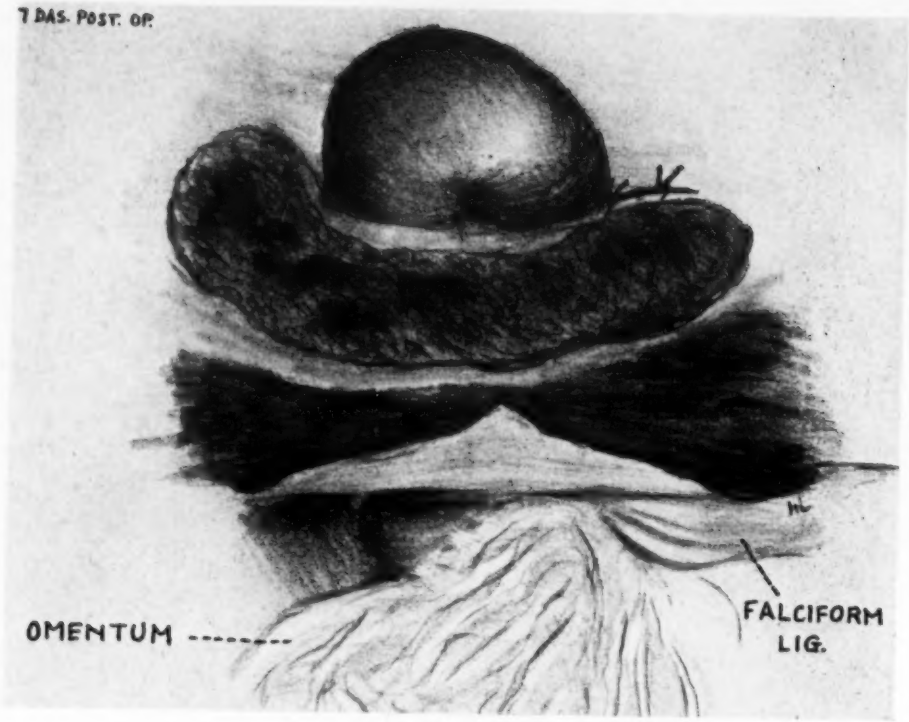

FIG. 19.

FIG. 18.—J-27. (See Table V.) Microphotograph to show the hæmorrhagic and œdematous wall of the invaginated portion of the jejunum.

FIG. 19.—J-41. (No. 1.) Drawing of experimental jejunojejunostomy in which the loop is left incarcerated within the abdominal wound. Although this principle is safe practice in conolic surgery, it appears hazardous in those cases in which the jejunum is used. Note acutely inflamed jejunal loop and sharply demarcated necrotic space containing characteristic red fluid (as in pancreatic digestion). It is considered safest to divide loop and leave ends at angles of wound as in Case J. J. M.

attached base and through the new vascular connections from the underlying serosa and overlying omentum. The intraperitoneal adhesions protect the body cavity from peritonitis and the omentum, besides protecting the stomatized loop from harmful adhesions, facilitates spontaneous closure of the ostomy. All considered, this technic varies so little from the one in

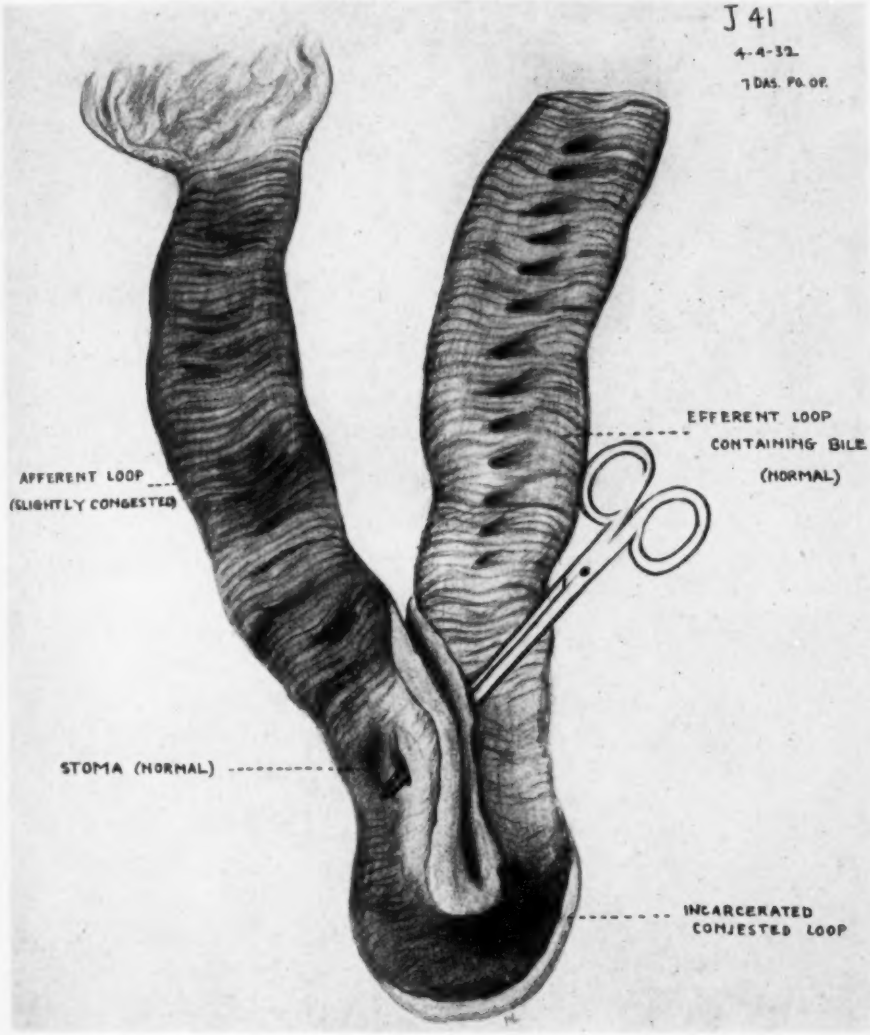

FIG. 20.—J-41. (No. 2.) Peritoneum clean. Obstruction from incarcerated loop. Great omentum + falc. lig. strongly adherent about anast. necrotic space, containing red fluid within wall of abdomen.

common usage, requires so little additional time to accomplish, and seemingly has so much more to recommend it, that the author does not hesitate at this time to suggest it.

CONCLUSIONS.—(1) Intestinal obstruction and peritonitis are considered essential causes of failure in a fair proportion of sudden deaths not attribut-

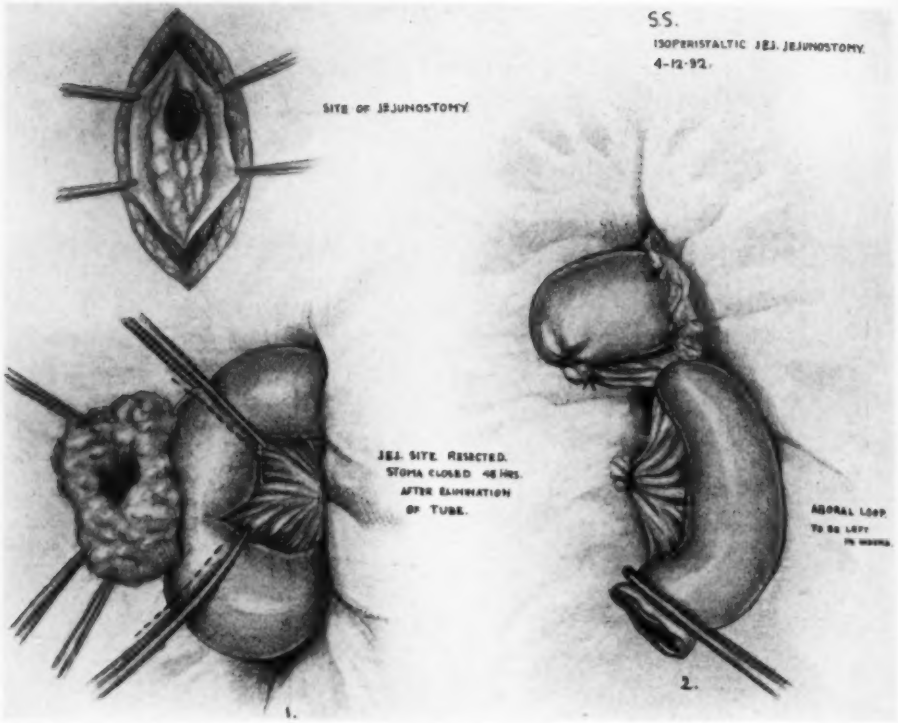

FIG. 21.—S. S. Drawing representing a secondary operation upon a carcinoma case. This case (S. S., Table I) had had a Stamm-Kader operation with graft and was satisfactory excepting for the difficulty in restraining tube from coming out. As in many similar cases it was necessary to reëstablish jejunostomy in the operating room. Note resection of old ostomy site with graft (1), closure of oral end and preparation of aboral end for jejunostomy (2). The jejunal stoma had entirely closed forty-eight hours after passing tube and jejunal loops were normal.

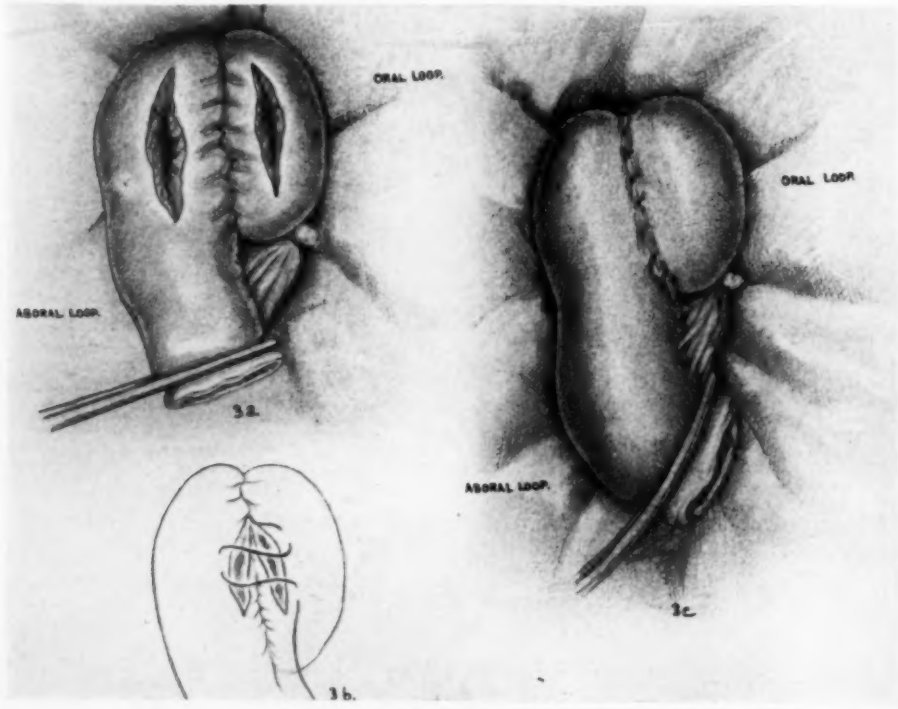

FIG. 22.—S. S. Lateral jejunojejunostomy, isoperistaltic. (Figs. 3a, b, c.)

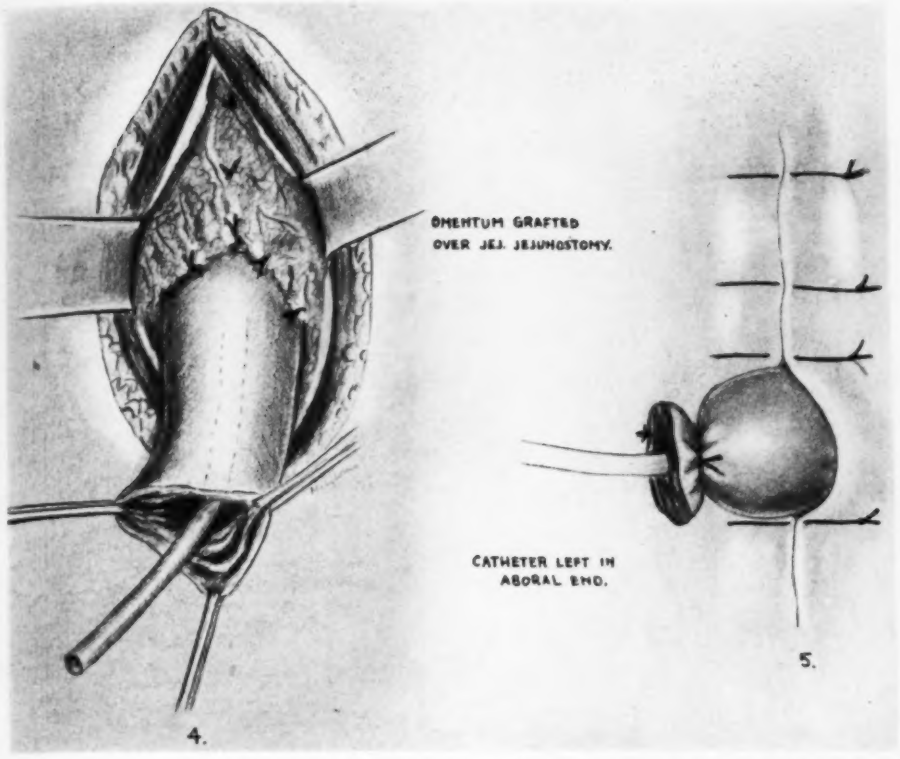

FIG. 23.—S. S. (Figs. 4 and 5.) Aboral jejunal end left to serve as a jejunostomy while the oral end remains within the abdomen directed caudad and away from the peritoneum.

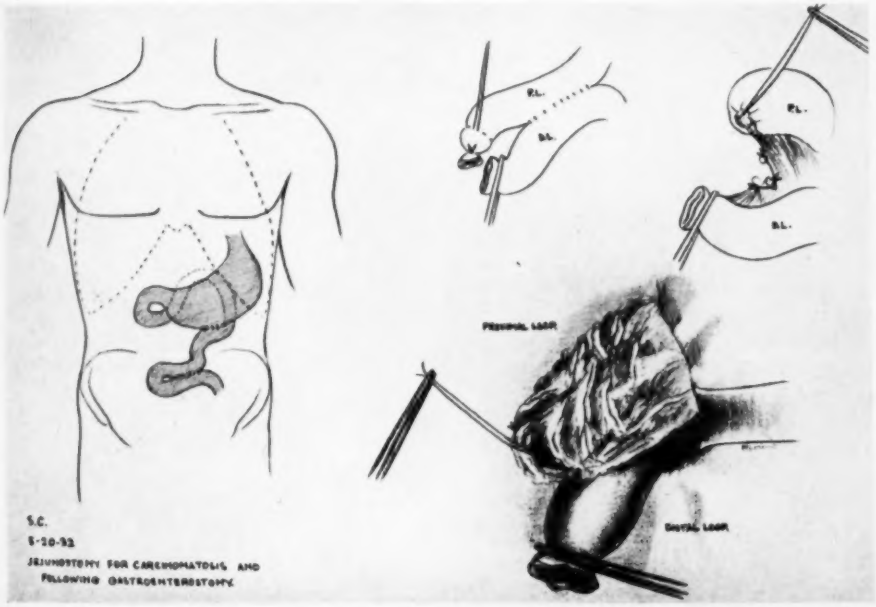

FIG. 24.—S. C. Drawing to illustrate an advanced carcinoma case upon whom a posterior gastrojejunostomy had been performed for malignancy at the pylorus. Extensions of growth into the mediastinum necessitated further relief. Jejunojejunostomy, lateral, antiperistaltic, with one end of jejunum in the peritoneal plane and the other reserved for jejunostomy, was attempted. Note omentum about anastomosis.

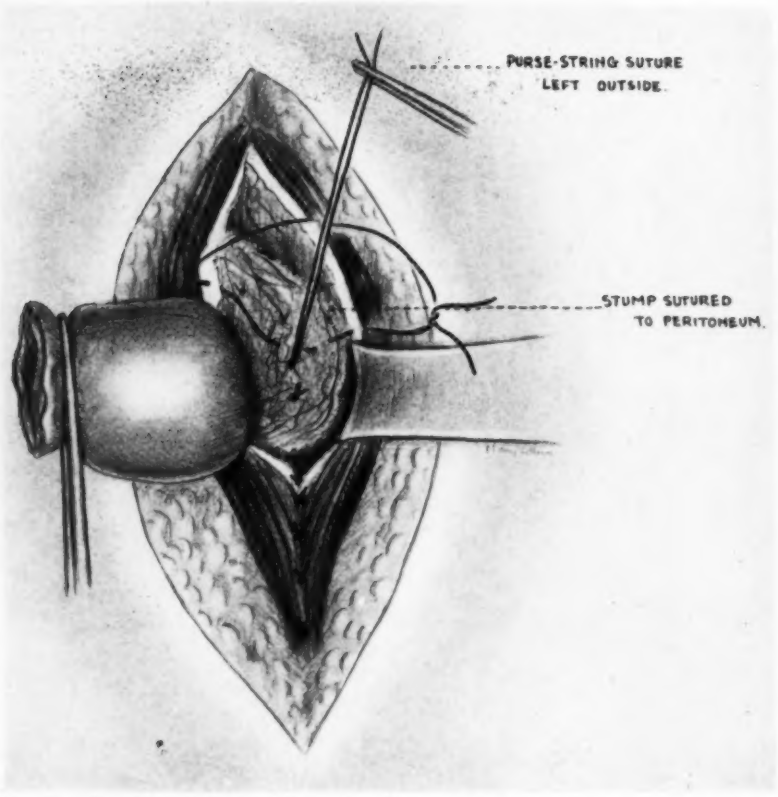

FIG. 25.—S. C. (Fig. 2.) Note ends of purse-string suture left out upon skin to facilitate reopening of stump if inflammation or obstruction occur.

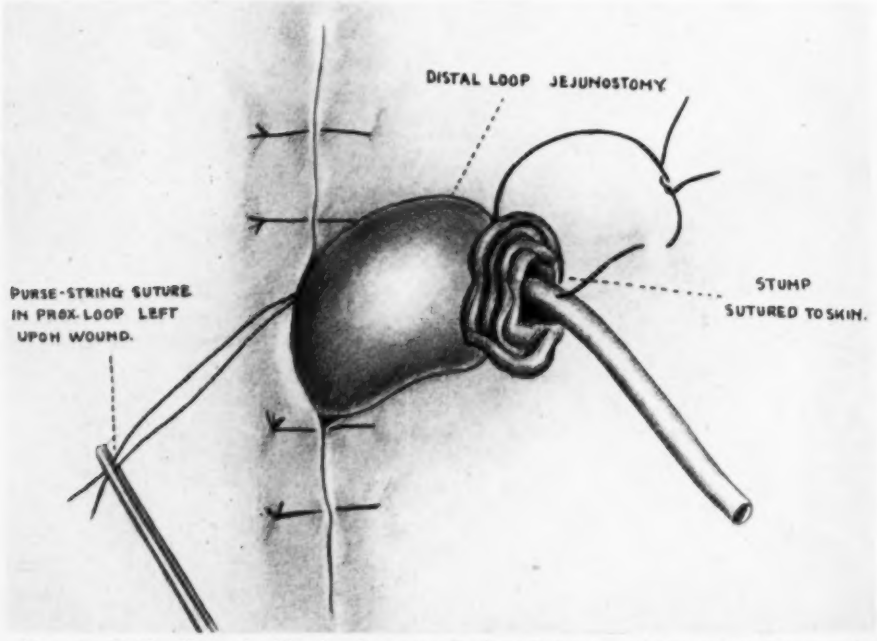

FIG. 26.—S. C. (Fig. 3.) Aboral end temporarily ligated about a catheter and to skin away from wound to protect wound from contamination. Catheter is left out between feedings.

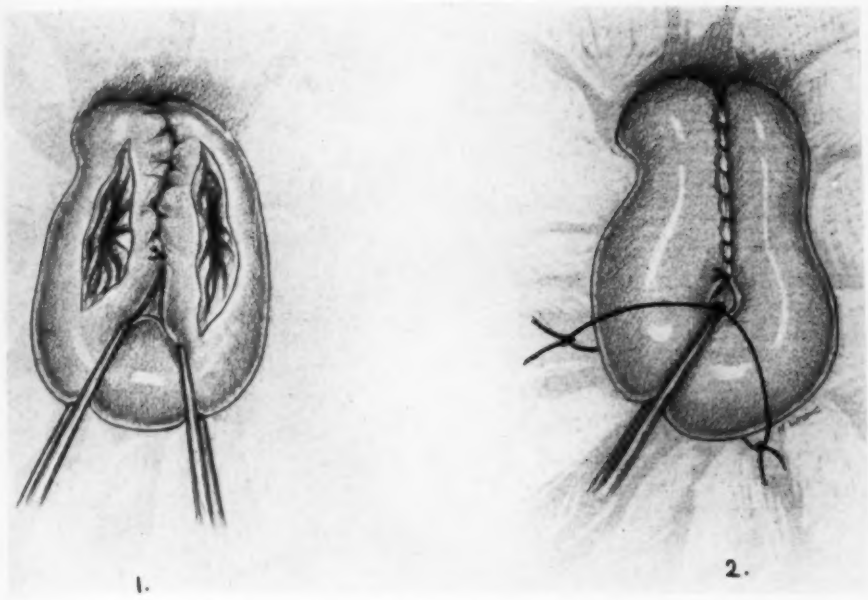

FIG. 27.—J. J. M. (Figs. 1 and 2.) Drawing illustrating lateral jejunojejunostomy with the loop drawn out as in the Mikulicz operation.

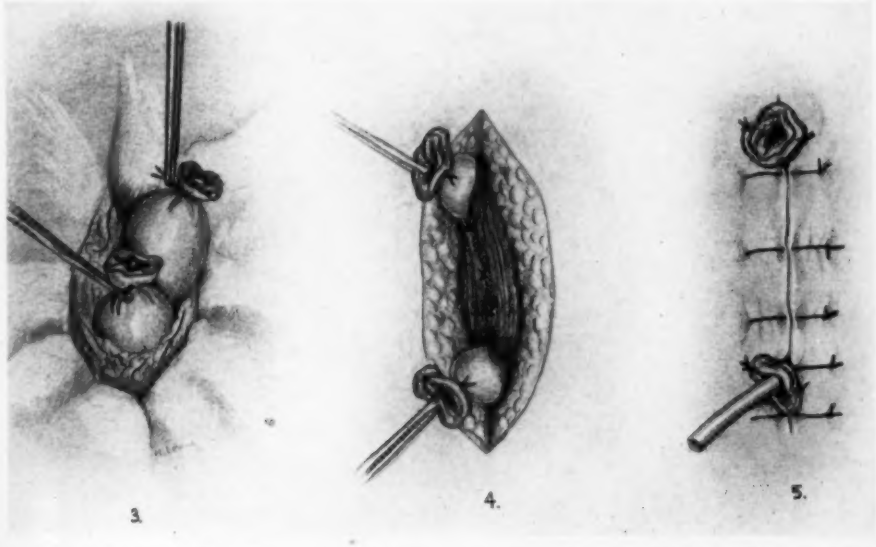

FIG. 28.—J. J. M. Figs. 3, 4, and 5 represent disposition of divided ends after lateral jejunojejunostomy. The ends are temporarily ligated and sutured to skin to prevent "spillage" of contents into wound. The aboral end is ligated about a catheter to facilitate early feeding but the catheter is left out between feedings after the first forty-eight hours.

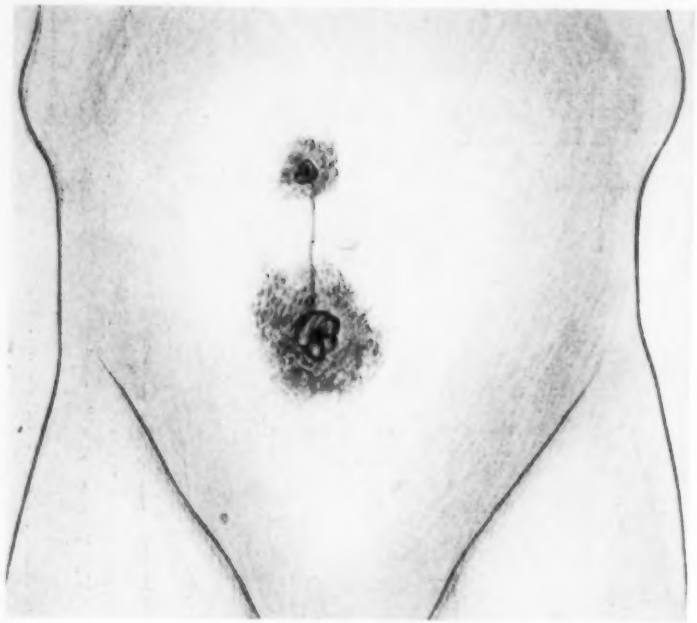

FIG. 29.

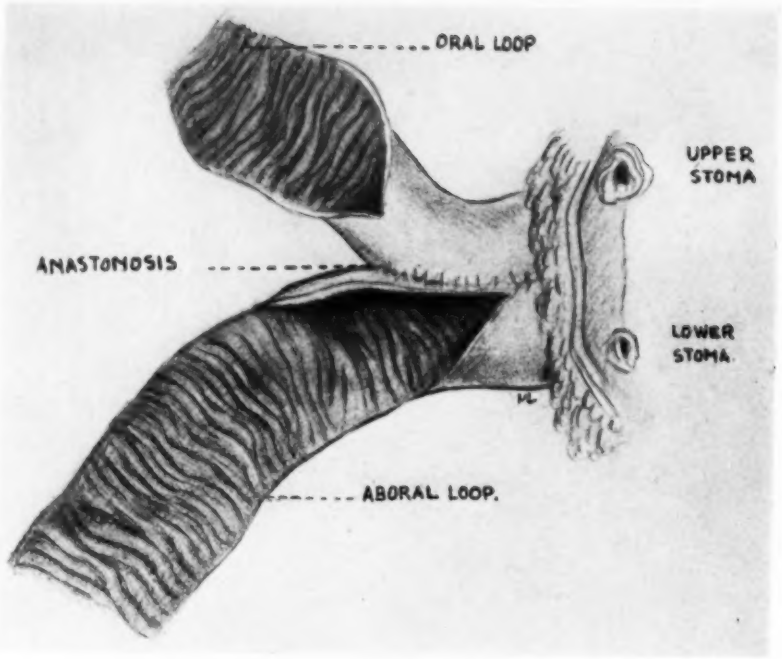

FIG. 30.

FIG. 29.—J. J. M. (Fig. 6.) Note degree of irritation of skin about jejunal stomata after forty-three days of jejunal feeding.
FIG. 30.—J. J. M. (Fig. 7.) Drawing to indicate the small degree of jejunal mucosal irritation following frequent daily jejunal feedings. The presence of the two open ends made it possible to divide the feedings between them.

able to systemic disease or new growth occurring within the first few days after jejunostomy.

(2) Symptoms and findings similar to those in acute high intestinal obstruction observed after jejunostomy are relieved by administering gastroduodenal secretions with the jejunal feedings.

(3) The present method of Witzel jejunostomy with peritoneal fixation appears safer than a similar one with interposed omentum.

(4) The Stamm-Kader or inversion technic appears to present less dangers from obstruction, necrosis, and perforation than the Witzel or invagination method.

(5) A method is recommended of utilizing a muscle-peritoneal graft which seals in the suture line, suspends the jejunal loop, provides for omental protection, and which is believed to favor spontaneous closure of the ostomy.

(6) It is suggested that jejunostomy with an indwelling catheter be reserved for those emergency cases in which jejunostomy is required for a few days only and that during this interval gastroduodenal secretions be collected and administered with the jejunal feedings.

One of the greatest concerns in the after-care of the jejunostomy patient is the catheter. There is fear of the tube coming out and fear of difficulty in replacing the tube. It has frequently been necessary to take these sick patients to the operating-room to re-introduce the tube, a procedure although minor, operatively, has repeatedly proved fatal to the patient. It is therefore recommended that the catheter technic described above be reserved for the acute emergencies, especially the occasional inflammatory case requiring jejunostomy but for a few days and that jejunostomy without the tube be carried out in those individuals having an expectancy of weeks to months.

Obviously jejunojejunostomy may be performed expeditiously and with little peritoneal traumata. By this procedure a continuity of the duodenojejunal tract is assured. Many variations in the methods of anastomosis have been advocated but the simplest and safest method seems to be the anastomosis of the adjacent walls of a jejunal loop pulled out as in the Mikulicz operation and protected by omentum. This technic appears below.

What to do with the jejunal loop has been the subject of experimentation and clinical observation. Experimentally, it is obvious that the jejunal loop cannot be treated as can a loop of colon. The loop has been left within the wound attached to the skin or has been brought out upon the skin. Such incarcerated loops may become deeply congested, allow the passage of digestive secretions through their walls, and cause necrosis within the wound. (See accompanying drawing, J.41, Numbers 1 and 2.) The jejunal loop may be divided and one or both ends left on the surface of the skin to one side or other of the wound as illustrated in the following clinical cases. (See drawings S.S., 1-5, S.C., 1-3, and J.J.M., 1-7.) Of these methods of disposing of the divided ends of the jejunum the third with both ends upon the skin has given the best results. It provides two stomata for feeding which is

fortunate when one becomes spastic from too much irritation. (J.J.M., Fig. 6.) It is believed that distension of the upper abdomen remains less. Furthermore, there is no possibility of contamination of the peritoneum or wound with secretions or with infectious material from the lumen of the bowel.

The improvement in the jejunitis observed in the few clinical cases in the Bellevue series is striking. The wearing of the catheter for a long period after jejunostomy must constitute a very important factor in such inflammation. This condition may be further relieved by extreme gentleness and cleanliness in the technic of feeding and by regularly introducing in small amounts at first properly heated peptonized food together with mucus, vitamins, and such enzymes and medications as may appear indicated. An attempt has been made to work up to a balanced diet and, in appropriate cases, to supply enough proteins to utilize the pancreatic secretion. Heyd[4] recommends a diet in the proportion of 100 grams of protein, 185 of fat, and 500 of carbohydrate. Whipple[5] feels there are advantages in sterilizing the fluid used in feeding jejunostomy cases. Liver, cod-liver oil, and ferric ammonium citrate, as advised by Wyckoff and Connery,[6] have been administered to relieve the secondary anæmias. It has been gratifying to note the increased comfort of these unfortunate patients and a revelation to find natural jejuna in the few cases observed after two or more months of this simple care. There is an occasional gain in weight and the patient may be up and about, either assisting in or attending to his feedings himself.

In conclusion, it is recommended that a permanent method of jejunostomy by which is meant jejunojejunostomy combined with the leaving of the divided ends outside of the wound and the entire doing away with the wearing of a catheter be utilized in inoperable cases requiring jejunostomy over protracted periods.

NOTE.—The author gratefully acknowledges the coöperation of Dr. G. D. Stewart, Dr. A. M. Wright, and his associates on the Third Division at Bellevue Hospital; Dr. I. Graef for assistance with the pathological material; Dr. Co-Tui, Dr. S. Nussbaum, Miss M. Lorenc, and the Experimental Staff at the University and Bellevue Hospital Medical College for valuable assistance in the experimental surgery and drawings.

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[1] Especially cases dying within forty-eight hours.

[2] Similar considerations would seem to apply to the care of the duodenal stump after gastric resection.

[3] Nussbaum informs me that the catheter used in the human cases (18 F.) is proportionately greater in circumference than that used in the experimental series.

[4] Heyd, C. G.: Am. Jour. Surg., vol. i, No. 4, pp. 188–191.

[5] Whipple, A.: Personal communication.

[6] Wyckoff, J., and Connery, J. E.: Personal communication.

AVERTIN ANÆSTHESIA

A STUDY OF 431 CASES COMPARED WITH 431 SIMILAR CASES OPERATED ON UNDER OTHER TYPES OF ANÆSTHESIA, AT THE BROOKLYN HOSPITAL

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of Brooklyn, N.Y.

Avertin anæsthesia was first used at the Brooklyn Hospital in October, 1930. During the next eighteen months it was used chiefly as a basal anæsthetic with increasing frequency. The majority of the staff, however, were never completely satisfied with the results attained. Only a few used avertin routinely for their ordinary surgical work. The level of anæsthesia produced often seemed very variable. In many instances peculiar, sometimes very disturbing post-operative reactions occurred. Finally in one week three patients who had had avertin died within forty-eight hours after operation, under rather peculiar circumstances, which it was feared might have some relation to the anæsthetic used. There was a growing feeling that avertin might not, after all, be the ideal, safe anæsthetic that it was supposed to be. Because of this feeling it was decided to make a careful statistical study of all the cases in which avertin had been used in the Brooklyn Hospital, and to compare this with a similar study of a control group of cases in the same hospital in which the ordinary routine anæsthetics—chiefly ether, gas-oxygen, or novocaine—were used. The control group was collected by listing in detail the types of operations done under avertin and selecting from the recent files of the hospital cases in which as nearly as possible exactly similar operations were done under other anæsthetics. A condensed, comparative list of the operations in the two groups of cases studied is given in Table I. The results of the comparative statistical studies of these two groups of cases form the basis of this report.

During the eighteen-month period included in this study avertin was used in 431 operations, or, roughly, 19 per cent. of all the operations performed at the hospital during this time, exclusive of operations in the Ear, Nose and Throat service. The type of operation in which avertin was used varied from complicated major operations to such minor procedures as excision of ingrown toe-nails, or circumcisions. About three-quarters of the operations were major operations. The group included patients of all ages from five to eighty-three years.

Properties of "Avertin Fluid."—The preparation of avertin which was used was "Avertin Fluid." (Winthrop.) This is a solution of tri-brom-ethyl-alcohol (avertin) and amylene hydrate in the proportion of 1 gram of avertin and ½ cubic centimetre of amylene hydrate to 1 cubic centimetre of solution. The avertin is the most potent part of the solution. The amylene hydrate is said to increase the solubility and rapidity of absorption of the

TABLE I

Comparative List of Operations

Operations	Avertin Group	Control Group
Cystotomy	9	9
Prostatectomy	7	7
Thyroidectomy (carcinoma)	1	1
Sub-total Thyroidectomy (adenoma)	6	6
Sub-total Thyroidectomy (Graves)	21	21
Lobectomy, Thyroid (adenoma)	6	6
Thyroidectomy, two-stage (Graves)	2	2
Cholecystectomy	9	9
Cholecystectomy and Gastroenterostomy	2	2
Cholecystotomy	2	2
Posterior Gastroenterostomy	4	4
Gastrotomy	1	1
Nephrectomy	6	7
Hemi-nephrectomy	1	
Pyelotomy	11	11
Pyelotomy and Nephrotomy	1	1
Ureterotomy	5	5
Radical Mastectomy	5	5
Simple Mastectomy	7	7
Excision Breast Tumor	6	6
Excision carcinoma axilla	2	2
Dilatation and curettage	15	15
Cæsarean section	13	13
Vaginal repair and insertion of Radium	14	14
Vaginal repair	33	33
Vaginal repair and Laparotomy	11	11
Suspension of uterus	6	6
Excision ovarian cyst	8	8
Salpingectomy	4	4
Salpingectomy and Appendicectomy	3	3
Supra-vaginal Hysterectomy	48	48
Hysterotomy	5	5
Thoracotomy with rib resection	14	14
Laminectomy	3	3
Inguinal hernia repair	22	22
Repair of inguinal hernia and hydrocele	4	4
Repair of strangulated inguinal hernia	2	2
Repair of femoral hernia	2	2
Repair of ventral hernia	1	1
Repair of strangulated ventral hernia	1	1
Appendicectomy	22	22
Appendicectomy with drainage	7	7
Mid-thigh amputation	3	3
Other operations (fifty-four different types)	74	74

avertin, but it must also exert a moderate hypnotic effect of its own, since the usual dosage of the solution contains 2 to 4 cubic centimetres of amylene of which the United States Pharmacopœia hypnotic dose is 3 to 5 cubic centimetres. The action of amylene is similar to that of paraldehyde but

two to three times as strong. "Avertin Fluid" is said to be rapidly absorbed from the rectum, about 80 per cent. in the first twenty minutes and 95 per cent. in the first two hours. During anæsthesia, concentration of avertin in the blood has been found to be around 6 to 9 milligrams per 100 cubic centimetres. Figures for the concentration of amylene hydrate have apparently not been published. After absorption through the blood the avertin is supposed to be rapidly detoxified by the liver; in Eicholtz's experiments this occurred at a rate faster than ether was exhaled. After detoxification, Parsons, Straub, and others have found that at least 98 per cent. is excreted by the kidneys, in combination with glycuronic acid, 70 to 80 per cent. within forty-eight hours, 90 to 95 per cent. within seven days.[1, 2, 3, 4, 5, 6, 7]

Method of Administration.—The system that was followed in administering the avertin anæsthesia was briefly as follows. An enema was given twelve hours before operation. On the supposition that supplementary anæsthesia might be needed the usual pre-ether orders of fluids until eight hours before operation, then nothing by mouth, were usually followed. In almost all cases except thyrotoxic patients (who were usually kept unaware of the impending operation), a pre-operative hypodermic of morphine and atropine was given shortly before the avertin—ideally twenty minutes before. In thyrotoxic patients a hypodermic of atropine alone was given shortly after the avertin. In the group of 431 cases 348 received morphine pre-operatively, usually with atropine, and forty-five received atropine alone. Others had pantopon, codeine, opium, or luminal. Only twenty-five had no pre-operative medication. Avertin with morphine seemed to produce a smoother basal anæsthesia than avertin alone, without excessive respiratory depression. The combination of pantopon with avertin, as used in six cases, seemed to depress respirations to an undesirable degree.

The avertin solution for each case was freshly prepared in the operating room from a concentrated stock solution, under the supervision of the anæsthesia department, with special attention to the proper temperature and to testing with Congo red for possible acid decomposition. The mixed solution was then quickly taken to the ward and injected slowly through a rectal catheter, the solution being re-tested for temperature and acid if there was any delay in preparing the patient.

After the avertin was given it was believed best to wait twenty minutes before attempting to start the operation. However, only 18 per cent. of the operations were actually started at the theoretically ideal time although over 98 per cent. of the patients were asleep within the twenty-minute interval. Two per cent. were started sooner than twenty minutes after, 47 per cent. between thirty and forty minutes after, 25 per cent. between forty and fifty minutes after, and 8 per cent. later than fifty minutes after the avertin was given.

This brings out one of the difficulties attached to the use of a fixed anæsthetic like avertin in a busy operating schedule. If the anæsthetist waits to mix and give the avertin (which must be prepared freshly in each case),

until after the operator has finished the preceding operation, the operator must wait thirty minutes or more before the patient is ready. If, on the other hand, the anæsthetist gives the avertin before the preceding operation is finished completely—which was necessary in a majority of the operations in this group—the operator may be delayed or interrupted, postponing the start of the operation beyond the ideal twenty-minute interval following the injection of the avertin. This delay is not of such importance, however, if avertin is used for basal anæsthesia only, as it was in most of these cases.

Dosage.—The dosage of avertin which was used varied considerably with the individual patient or operator, ranging from 60 to 100 milligrams per kilo. Two hundred eighty-three received the top dose of 100 milligrams; 120, 80 milligrams; thirteen, 90 milligrams; eleven, 60 milligrams; and two, 70 milligrams. In general, the lowest doses (60 to 70 milligrams) usually produced sleep without anæsthesia; the 80- to 90-milligram doses, deep sleep with a moderate degree of surgical anæsthesia in some cases; and the 100-milligram dose deep sleep with complete surgical anæsthesia in a few cases only, but with moderate anæsthesia in most of the cases. The size of the dosage also had a considerable effect on the rapidity of induction. With a 100-milligram dose, 81 per cent. of the patients were asleep within ten minutes and all but two of the remainder within twenty minutes, while with 80 milligrams only 54 per cent. were asleep within ten minutes and all but three of the rest asleep within twenty minutes. The duration of sleep showed a similar but less marked relation to the dosage. (Table III.) As mentioned above, however, the level of anæsthesia even with the same dose per kilo varied greatly with different patients.

Supplementary Anæsthesia.—Supplementary anæsthesia was needed in all but fifty-two of the 431 cases, since avertin was used chiefly as a basal anæsthetic to initiate and maintain unconsciousness without producing complete pain anæsthesia or muscular relaxation. Gas-oxygen was added in 205, gas-oxygen and ether sequence in 152, and novocaine local infiltration in 22. More supplementary anæsthesia was needed with the smaller than with the larger doses of avertin. The figures for the 431 cases show that with a 100-milligram dose, 16 per cent. required no supplementary anæsthesia, 49 per cent. were carried on gas-oxygen, and only 30 per cent. required ether, while with the 80-milligram dose only 7 per cent. required no supplementary anæsthesia, 41 per cent. were carried on gas-oxygen, and 47 per cent. required ether. In the remaining cases the avertin was supplemented by local anæsthesia.

On theoretical grounds it would seem that the ideal supplementary anæsthetic for avertin should be novocaine local infiltration. In many of the cases included in this study, however, it was found that although avertin when combined with local anæsthesia produced insensibility to pain and often amnesia, voluntary movements, and in many cases speech, were not always abolished and the patient would occasionally move or talk at an extremely inconvenient moment. In such instances the patient would not respond to

orders or requests as he would under ordinary local or spinal anæsthesia. A few experiences with patients who insisted on talking while the operator was attempting to reduce a hernia or who tried to put their hands in the wound showed that avertin and local anæsthesia were not always as ideal a combination as might be thought.

In order to determine what type of supplementary anæsthesia was usually needed to obtain satisfactory anæsthesia for different types of operation, a special study was made of the kind of anæsthesia used for the more common operations with and without avertin. The results of this study are shown in Table II. The figures in this table show that with avertin a great number of major operations were done without the use of ether, which previously required full ether anæsthesia. Over 50 per cent. of the major operations in this group were done satisfactorily under the combination of gas-oxygen and avertin. In the control group, less than 6 per cent. of the major operations could be done under gas-oxygen without ether. On the other hand, there were a few operations such as cystotomies and rib-resections which were previously done chiefly under local anæsthesia with no inhalation anæsthesia, which required supplementary inhalation anæsthesia when avertin was used. All of the cystotomies and all but five of the fourteen rib-resections in the control group were done with local anæsthesia. When avertin was used instead of local it was found necessary to resort to supplementary

TABLE II

Type of Supplementary Anæsthesia Used for Different Types of Operations

Operation	Avertin Group				Control Group			
	Ether	G.O.	Local	None	Ether	G.O.	Local	Other
Cystotomy (9)	5	2	0	2	0	0	9	0
Prostatectomy (7)	3	3	0	1	4	0	3	0
Thyroidectomy (38)	7	29	0	2	26	12	0	0
Cholecystectomy (11)	7	3	1	0	11	0	0	0
Cholecystotomy (2)	0	1	1	0	2	0	0	0
Gastroenterostomy (4)	2	2	0	0	3	0	0	1
Gastrotomy (1)	1	0	0	0	1	0	0	0
Pyelotomy (12)	2	9	0	1	12	0	0	0
Nephrectomy (7)	1	6	0	0	7	0	0	0
Ureterotomy (5)	0	5	0	0	5	0	0	0
Breast operation (20)	3	13	1	3	18	2	0	0
D. and C. (15)	1	9	0	5	15	0	0	0
Vaginal repair (47)	10	27	0	10	46	0	0	1
Vag. and Lap. (11)	7	2	1	1	11	0	0	0
Suspension uterus (6)	2	4	0	0	5	0	0	1
Salpingectomy, *etc.* (15)	9	2	0	4	15	0	0	0
Hysterectomy (48)	35	10	1	2	46	0	0	2
Hysterotomy (5)	1	2	0	2	3	0	2	0
Repair hernia (35)	10	14	10	1	23	0	11	1
Rib-resection (14)	1	11	1	1	1	4	9	0
Appendicectomy (29)	18	10	1	0	27	0	0	2
Totals (341)	125	164	17	35	281	18	34	8

inhalation anæsthesia in seven of the nine cystotomies and twelve of the fourteen rib-resections.

Post-operative Course after Avertin.—One of the chief advantages argued for avertin has been that the post-operative course is unusually smooth and comfortable for the patient, due chiefly to three factors: (1) The prolonged sedative effect of the bromide-containing avertin, which produces stupor and drowsiness for several hours after operation and amnesia for a considerable part of the same period; (2) absence or diminution of the usual disturbing post-anæsthetic vomiting; (3) decrease of post-operative respiratory complications. In this group of cases the following effects in relation to these three factors were noted.

(1) *Post-operative Sedative Effect.*—With the ordinary forms of anæsthesia, as used in the control group of cases—gas-oxygen or gas-oxygen and ether—the patients usually awoke within a short time after the anæsthesia was stopped, passing through a fairly short excitement stage. When avertin was used as a basal anæsthetic, this awakening stage was much delayed and the short excitement period was replaced by a much longer period of intermittent restlessness of varying degree. The length of unconsciousness following avertin varied somewhat with the dosage but not as much as might be expected. None of the patients were awake within less than one hour. A few slept for six to eight hours or longer. (Table III.) The average duration of deep sleep with the 80 to 100 milligrams per kilo doses was two to five hours, which was followed by a period of drowsiness for four to twelve hours longer, interrupted in many cases by periods of restlessness often requiring morphine or a similar sedative. During this period of drowsiness and restlessness anæsthesia did not persist, so that morphine was often necessary also to control post-operative pain. Of the avertin cases post-operative restlessness was marked enough to be mentioned in 38 per cent. of the cases and was very marked in 14 per cent. Three hundred twenty-eight of the patients or 76 per cent. required post-operative morphine or a similar sedative to control restlessness or pain within the first twelve hours after operation. In the control cases restlessness was mentioned in only 21 per cent. and very marked restlessness in only 8 per cent. Three hundred four or 70 per cent.

TABLE III

Duration of Sleep after Avertin

Time of Awakening after Avertin Given	100 Milligrams per Kilo	80 Milligrams per Kilo
less than 1 hr.	0	0
1 to 1½ hrs.	.3%	3 %
1½ to 2 hrs.	7 %	15 %
2 to 3 hrs.	38 %	41 %
3 to 4 hrs.	32 %	25 %
4 to 5 hrs.	15 %	12 %
5 to 6 hrs.	4 %	2 %
6 to 7 hrs.	3 %	1.5%
over 7 hrs.	.7%	.5%

required morphine or similar sedative within the first twelve hours after operation.

This longer duration of unconsciousness and irregular as well as increased restlessness after avertin meant that it was necessary to give avertin patients special post-operative care for a much longer period than with other anæsthetics. The patient was undoubtedly much more comfortable—especially since the events of the first few hours after operation were usually entirely forgotten—but the nursing problem of the hospital was greatly increased. The patients appeared just as irresponsible during the prolonged drowsy, restless period of awakening from avertin as during the shorter excitement stage following ether.

(2) *Post-operative Vomiting.*—Post-operative vomiting was mentioned in the nurses notes in 242 or 56 per cent. of the control group of cases. Of these, 39 per cent. had only slight vomiting, and 61 per cent. moderate or marked vomiting. In the avertin group similar mention of vomiting was found in 181, or 42 per cent. of the cases (14 per cent. less than in the control group) and the severity of vomiting was also less, only 46 per cent. instead of 61 per cent. having moderate or marked vomiting. As shown in Table IV this decrease appeared to be due in large part to the decreased use of ether, first by using smaller amounts of ether when ether was needed to supplement the avertin, and secondly by substituting gas-oxygen for ether in a large number of cases (the incidence of vomiting following the gas-oxygen and avertin combination being much less than that after either gas-oxygen or ether alone). Since vomiting following gas-oxygen alone is usually immediately after operation and of short duration, the comparative absence of vomiting after the gas-oxygen-avertin combination may probably be explained as due to suppression of the nausea reflex by the avertin during the immediate post-operative period.

TABLE IV

Incidence of Post-operative Vomiting

	Avertin Group		Control Group	
Total number, vomiting	181		242	
Total per cent, vomiting	42%		56%	
Slight vomiting		54%		39%
Marked or moderate vomiting		46%		61%
Of cases having ether, vomiting	55%		60%	
Slight vomiting		53%		34%
Marked or moderate vomiting		47%		66%
Of cases having gas-oxygen, vomiting	39%		67%	
Of cases having no inhalation anæsthesia, vomiting	20%		19%	

The incidence of post-operative vomiting also varied somewhat with the type of operation performed. In operations such as appendicectomy, cholecystectomy, hysterectomy and thyroidectomy, where factors other than the anæsthesia presumably play a prominent part in the production of vomit-

ing, the incidence was practically the same in both avertin and control cases. But in other operations as in vaginal, breast, hernia or orthopædic cases, where there would presumably be little except the anæsthetic to cause vomiting, the incidence was much higher in the control cases than in the avertin cases. This difference was especially marked in the orthopædic operations, vomiting occurring in ten cases in the ether group and in only one of the avertin cases.

(3) *Post-operative Respiratory Complications.*—In studying post-operative respiratory complaints a list was made of all cases in which cough or other respiratory symptoms were mentioned in the nurses or doctors notes within three days after operation. These cases were then studied in detail as regards pre-operative cardio-respiratory symptoms, type of anæsthetic used, type of operation performed, and severity and duration of post-operative symptoms.

Post-operative respiratory complications were found to have occurred in a considerably larger number of cases in the avertin group—in eighty-six cases or 20 per cent., as against seventy-one cases or 16 per cent. of the control group. There were, however, a great many more pre-operative cardiac and respiratory complications in the avertin group, since avertin was quite frequently used as a basal anæsthetic in the presence of cardiac or respiratory pathology with the idea of reducing the amount of inhalation anæsthesia, especially ether, used. Excluding all these cases with pre-operative cardiac or respiratory complications, the incidence of post-operative respiratory troubles in the remaining cases was much higher in the control group in the ratio of 30 to 21. The incidence of the more serious post-operative respiratory complications—acute bronchitis and bronchopneumonia—was also much higher in the control group, in a ratio of 16 to 8.

The thirty control cases and the twenty-one avertin cases which had no local cardio-respiratory complications before operation were studied in more detail. Of the thirty control cases twenty-nine (97 per cent.) had had ether anæsthesia, although ether was used in only 82 per cent. of the control group of 431 cases as a whole. Of the twenty-nine cases which had ether, thirteen had serious respiratory complaints—seven pneumonia, and six bronchitis. Of the twenty-one avertin cases eleven had had supplementary ether, seven gas-oxygen and three avertin alone. Two of the eleven ether cases had pneumonia. The others had minor respiratory complaints.

In the cases which had cardiac or respiratory complications before operation there was no difference in the gross incidence of post-operative respiratory complaints when avertin was used. In the avertin and the control group of cases almost exactly the same proportion—one-third—of the cases in each group with pre-operative cardio-respiratory complications had respiratory symptoms post-operatively. However, in studying the cases individually, it is evident that avertin was used to apparent advantage in several cases with chronic bronchitis, asthma and pulmonary tuberculosis, except in the cases for which ether was also used. Only five of seventeen cases with chronic

bronchitis which received avertin without ether were made worse by operation as against two of three ether cases in the control group and two of three avertin-ether cases. Four control cases with chronic bronchitis which had local anæsthesia were not worse after operation. None of the sixteen avertin cases with pulmonary tuberculosis appeared to be aggravated following anæsthesia, while one case in the control group which had a full ether anæthesia had a very severe reactivation of his pulmonary tuberculosis.

These findings suggest that in some cases which were given avertin basal anæsthesia, the susceptibility to post-operative respiratory complications was reduced. Although these cases are too few in number to permit drawing any definite conclusion from them, it would seem that this reduction, as the reduction in post-operative vomiting, might be largely attributed to the decreased use of ether.

Avertin was used to less advantage in severe cardiacs. Two patients with a severe degree of cardiac disease became much worse after the avertin was given, before any operative procedure was started; and of all the cardiacs in both groups one-third of the avertin group and only one-fourth of the control group were made temporarily worse following operation.

Avertin was also used to less advantage in empyæmas. Of the fourteen empyæma cases in each group, eleven of the avertin cases required gas-oxygen and one ether, while gas-oxygen was required only four times and ether once in the control cases, the remaining nine cases being done satisfactorily under local anæsthesia.

Post-operative Pneumonia and Bronchitis.—As mentioned before, the incidence of post-operative bronchopneumonia and acute bronchitis was considerably lower in the avertin group—in fact just half that of the control cases—as follows:

Control group			
Bronchitis	7		
Bronchopneumonia	9	Total	16
Avertin group			
Bronchitis	1		
Bronchopneumonia	7	Total	8

In the control group six of the seven bronchitis cases and seven of the nine pneumonias were not preceded by any pre-operative cardiac or respiratory complaints. Of the other two pneumonias, one had partially decompensated rheumatic heart disease pre-operatively, the other acute pharyngitis complicating toxæmia of pregnancy. All these cases received full ether anæsthesia for a more or less prolonged period. The other case of bronchitis followed a second-stage prostatectomy under local anæsthesia, in an old man of eighty-four years with marked arteriosclerosis and hypertension, and was evidently a purely hypostatic condition. In all except one, of the pneumonia and bronchitis cases in the control group, therefore, the suspicion rests

very strongly on the prolonged ether anæsthesia as being the critical causative factor.

Of the seven avertin cases which developed post-operative pneumonia, five had ether for longer than thirty minutes. Three of these had no pre-operative cardio-respiratory complaints and the other two were cardiacs of moderate degree, one of whom expelled most of the avertin and had practically a full ether anæsthesia. In the majority of these cases also, suspicion is directed toward the ether anæsthesia as the critical etiological agent. The other two cases of pneumonia in the avertin group were rather mild. One developed in a twenty-six-year-old man, with bronchiectasis and chronic asthma, who had an inguinal hernia repaired under avertin and local. The second developed in a woman of seventy-five years with marked arteriosclerosis, who had a simple mastectomy under avertin and gas-oxygen. The one case of bronchitis followed a cholecystectomy under avertin and gas-oxygen in a woman of fifty-two who had an acute upper respiratory infection at the time of operation.

Avertin and Kidney Function.—Avertin was used in twenty-four cases on which kidney operations were performed, *i.e.*, twelve pyelotomies, seven nephrectomies, and five ureterotomies. Because avertin is excreted almost solely by the kidneys, it was thought of interest to study the effect of avertin on kidney function in these cases. Of the thirty-four cases in both groups in which satisfactory data was available, half showed some impairment of kidney function before operation, the other half showed normal function. The proportion of cases showing normal and impaired function pre-operatively was practically the same in the avertin and in the control group. Accurate figures for kidney function immediately after operation were not available, but a fairly good idea of gross kidney function could be obtained from the figures on intake and output. The average pre-operative and post-operative urinary output for the control and the avertin groups was almost exactly the same. The average output for the first twenty-four hours after operation was in both groups approximately 33 per cent. of the output for the twenty-four hours immediately preceding the operation. The average fluid intake was also almost exactly the same in both groups for the first twenty-four hours post-operative.

Judged on the basis of urinary output for a given fluid intake, therefore, following similar kidney operations, the post-operative depression of kidney function was no greater after avertin than after ether anæsthesia; and, as far as could be determined clinically, there was no other evidence of injurious renal effect when avertin was used for kidney operations. However, the marked depression of urinary output which occurred following kidney operations, sometimes lasting forty-eight hours or longer (Table V) meant that the excretion of avertin must in these cases have been proportionately delayed. For this reason, until it is known definitely that the avertin product which is retained in the body is harmless, it would seem wiser not to use avertin for

cases with impaired kidney function or for kidney operations where the kidney function is likely to be depressed for several days after operation.

TABLE V

Kidney Function after Kidney Operations

	Avertin Group	Control Group
Normal function pre-operative	54%	46%
Impaired function pre-operative	46%	54%
Average output twenty-four hours pre-operative	57 oz.	50 oz.
Pyelotomies	47 "	54 "
Ureterotomies	61 "	53 "
Nephrectomies	65 "	37 "
Average output twenty-four hours post-operative	19 oz.	16½ oz.
Pyelotomies	20 "	21 "
Ureterotomies	14 "	11 "
Nephrectomies	21½ "	12 "
Percentage post-operative of pre-operative output	33%	33%
Pyelotomies	42%	40%
Ureterotomies	23%	21%
Nephrectomies	33%	33%
Average intake twenty-four hours post-operative	44 oz.	43½ oz.
Pyelotomies	45½ "	45 "
Ureterotomies	52 "	46 "
Nephrectomies	35 "	38 "

Avertin and Thyroid Operations.—There was one type of operation for which avertin was considered to be in many ways ideal—namely, thyroid operations. With avertin the pre-anæsthetic excitement and apprehension could be eliminated entirely in most cases and when desired the patient could usually be kept unaware of the time or day of operation, since the pre-operative routine procedure used was almost identical with the procedure followed before basal metabolism. No local preparation was done and no hypodermic given until after the avertin had been administered. In addition the use of ether in thyroid cases was very markedly decreased, ether being used in only seven of the avertin group as against twenty-six of the control group. In all except two of the remainder of the avertin-thyroid cases supplementary gas-oxygen was used, usually without attempting to start the operation under avertin alone.

It was felt that the prolonged sedative effect of avertin might also be of benefit in these thyroid cases, but this was not found to be especially true. In the avertin group, all of which had received thorough pre-operative preparation, a few rather severe post-operative thyroid reactions were encountered which it was felt were more pronounced than might ordinarily be expected. In line with the theory that bromine might displace, or at least conflict with, the action of iodine in the body, it was suggested that the unexcreted bromine

of the avertin might be diminishing the beneficial effect of the Lugol's solution given before and after operation, or in some other way be having a disadvantageous effect on the thyroid-iodine relation. With this in mind a detailed study was made of the temperature reactions during the first five days after operation in all the thyroid cases which received avertin and in a carefully selected control group of thyroid cases. (Table VI.) The number of cases which averaged practically normal temperatures post-operatively—daily average under 100°—was the same in both groups, only nine each. In the remaining cases there appeared to be little difference in the degree of temperature reaction between the avertin and control cases. There were a few more severe reactions in the avertin group but hardly enough to be significant. The slight difference might quite readily be due to other factors. Taking everything into consideration, therefore, there did not seem to be any real evidence that post-operative thyroid reactions were increased in number or degree following avertin, or on the other hand that avertin had any especial beneficial post-operative effect in thyroid cases.

TABLE VI

Temperature Reaction after Thyroidectomies

	Avertin Group	Control Group
Average daily temperature under 100°		
1st day post-operative	19	17
2nd day post-operative	12	12
3rd day post-operative	16	24
4th day post-operative	29	30
Average daily temperature 100° to 101°		
1st day post-operative	10	14
2nd day post-operative	12	10
3rd day post-operative	15	6
4th day post-operative	2	5
Average daily temperature 101° to 103°		
1st day post-operative	5	4
2nd day post-operative	6	12
3rd day post-operative	1	5
4th day post-operative	0	0
Average daily temperature over 103°		
1st day post-operative	0	2
2nd day post-operative	4	0
3rd day post-operative	0	0
Highest average daily temperature under 100°	9	9
Highest average daily temperature over 101°	14	17
Highest single temperature under 100°	0	1
Highest single temperature over 101°	28	23
Highest single temperature over 103°	6	5
Highest single temperature over 105°	4	2

Avertin Headache and Other Post-operative Complications.—Several patients who had had avertin anæsthesia complained a few hours after operation of a severe headache lasting twenty-four to seventy-two hours. This headache in many instances seemed much more distressing and persistent than the usual type of post-operative headaches. On checking through the nurses notes mention of headache within the first thirty-six hours after operation was found almost twice as frequently in the avertin group of cases (16 per cent.) as in the control group (9 per cent.). In the cases in which this severe headache occurred without other evident cause it seemed probable that it was a toxic after-effect of the avertin (tri-brom-ethyl-alcohol) possibly similar to the well-known hangover headache from ordinary ethyl-alcohol.

Other post-operative complications following avertin anæsthesia, many of them toxic in nature, were noted but not studied in detail. A list of these is given in Table VII. There was only one instance of diarrhœa following the administration of avertin. This was in an eight-year-old girl who had a plastic operation for a scar on the neck. She had watery diarrhœa associated with urinary frequency and urgency for thirty-six hours, after which she had no recurrence of rectal or urinary symptoms. An erosion of the rectum was found at post-mortem twelve days after operation in one case, but since this patient had a pelvic abscess secondary to a ruptured appendix it is improbable that the erosion of the rectum had much to do with the rectal anæsthetic. One patient, a boy of fourteen with Fröhlich's syndrome, who had been operated on under avertin for ingrown toe-nail, developed what appeared to be a bromide rash on the second day post-operative. Several cases showed some mental changes for a few days post-operatively—melancholia, mental confusion, excessive nervousness, *etc.* One patient had an unexplained convulsion, another an unexplained chill, which were thought to be possible reactions from the avertin anæsthetic. There were a few cases of post-operative paralytic ileus which could not be well explained except as post-anæsthetic effects.

Post-operative Mortality after Avertin.—Of the 431 cases in the avertin group twenty-seven, or 6 per cent., died before leaving the hospital as against twenty-four, or 5½ per cent., of the 431 cases in the control group. The slightly larger number of fatalities in the avertin group may be, at least partly explained by the fact that a proportionately larger number of the poor surgical risks were given avertin in preference to other anæsthetics with the idea that it would be a safer anæsthetic. This was especially true during the first twelve months of the eighteen-month period when 8 per cent. of the cases operated under avertin were classified as poor risks and 27 per cent. as fair risks, as compared to the average in the control group of 4 per cent. poor risks, and 16 per cent. fair risks. Of the whole group of 431 avertin cases there were about 10 per cent. fewer good risks than in the control group. Of the avertin cases which died, nine were classified pre-operatively as poor risks as opposed to six in the control group.

Only ten of the avertin cases, or 2.3 per cent. died within forty-eight hours after operation from immediate or delayed post-operative reactions. These

TABLE VII

Other Post-operative Complications

Avertin Group

Operation	Complication	Result
Appendicectomy	Unusually long coma	Rec.
Hepatico-duodenostomy	Coma 7 hrs. and post-operative shock	Died
Insertion radium cervix	Post-operative chill, deep coma 24 hrs.	Rec.
Orchidectomy and hernia repair	Coma 11 hrs. and post-operative shock	Died
Exploratory laparotomy	Marked cyanosis, respiratory and circulatory depression	Died
Cervical sympathectomy	Marked cyanosis	Rec.
Exploratory laparotomy (hepatitis)	Marked cyanosis, coma 8 hrs.	Rec.
Thyroidectomy	Marked cyanosis. Acute degeneration liver, kidneys, heart, lungs, *etc.*	Died
Incision abscess groin	Marked respiratory depression, 4 hrs.	Rec.
Open reduction	Marked respiratory depression, 4 hrs.	Rec.
Cystotomy	Marked respiratory depression, 12 hrs.	Rec.
Cholecystotomy	Hypoglycæmic shock, several days	Rec.
Cholecystectomy and Posterior Gastroenterostomy	Post-operative shock	Rec.
Repair ventral hernia	Post-operative shock and cardiac failure	Died
Vaginal repair	Marked post-operative shock	Rec.
Vaginal repair	Severe shock, anuria and toxemia	Died
Hysterectomy	Post-operative hæmorrhage, 3rd day	Rec.
Prostatectomy	Post-operative hæmorrhage, 9th day	Died
Thyroidectomy	Post-operative hæmorrhage, 12 hrs. and crisis	Rec.
Thyroidectomy	Thyroid crisis and cardiac failure	Died
Thyroidectomy	Massive collapse of lung and thyroid crisis	Died
Thyroidectomy	Acute pulmonary œdema, 1 hr. post-operative	Died
Mid-thigh amputation	Gas-gangrene and acute toxæmia	Died
Vaginal and Laparotomy	Very nervous with tremor, 3 days	Rec.
Appendicectomy	Melancholia several days	Rec.
Excision cyst, breast	Dizziness, 48 hrs.	Rec.
Cholecystectomy	Cystitis	Rec.
Laminectomy	Cystitis	Rec.
Hysterectomy	Cystitis	Rec.
Appendicectomy	Cystitis	Rec.
Salpingectomy	Pyelitis	Rec.
Suspension uterus	Pyelitis	Rec.
Hysterectomy	Cystitis and phlebitis	Rec.
Cholecystectomy	Phlebitis	Rec.
Appendicectomy	Inability to void, 6 days	Rec.
Plastic, neck	Frequency, urgency, diarrhœa, 36 hrs.	Rec.
Appendicectomy (pelvic abscess)	Paretic ileus, erosion rectum	Died
Appendicectomy	Intest. obstruction (? paretic ileus)	Died
Cæsarean	Intest. obstruction (? paretic ileus)	Died
Nephrectomy	Paretic ileus	Died
Appendicectomy	Paretic ileus	Rec.
Inguinal hernia repair	Paretic ileus	Rec.
Supra-vaginal hysterectomy	Peritonitis	Died
Onychectomy	Bromide rash	Rec.

ten and one other which died on the sixth day post-operative from unexplained persistent paralytic ileus are the only ones in which it was felt that the

anæsthesia might be suspected of contributing in any way to the fatality. Of the control group eight died within forty-eight hours post-operative and one other died seventy-two hours after operation with complete anuria which started following operation. All the other deaths in both avertin and control groups occurred from obvious secondary causes or too long after operation to be connected with the anæsthesia. (Table VIII.)

TABLE VIII

Deaths—Avertin Group

(1) Ruptured Appendix. Died 12th day of peritonitis.
(2) Supra-vaginal Hysterectomy. Died 56 hours of peritonitis.
(3) Acute Intestinal Obstruction—Internal Hernia. Died 8th day post-operative of unrelieved obstruction.
(4) Acute Intestinal Obstruction. Died 5th day of unrelieved obstruction and terminal pneumonia.
(5) Strangulated Hernia, 6 days with gangrene and intestinal obstruction. Died 50 hours of recurrent obstruction.
(6) Acute appendix. Died 10th day of intestinal obstruction (paralytic ileus).
(7) Cæsarean. Died 5th day of intestinal obstruction (paralytic ileus).
(8) Prostatectomy. Died 9th day of post-operative hæmorrhage.
(9) Prostatectomy. Died 5th day of cardiac failure.
(10) Cystotomy. Died 5th day of post-operative pneumonia (avertin expelled).
(11) Ulcer of Cæcum. Died 13th day of cardiac failure.
(12) Cholecystectomy. Died 40th day of exhaustion following post-operative pneumonia.
(13) Exploratory Laparotomy. Died 28th day of chronic leucæmia and terminal pneumonia.
(14) Dilatation and Curettage. Died 30th day of multiple sclerosis.
(15) Carcinoma of Sigmoid with chronic obstruction. Died 40th day post-operative of cachexia.
(16) Supra-vaginal Hysterectomy. Died 21st day, 2 days after second operation (resection of the rectum under spinal).

Plus eleven deaths discussed in text.

Deaths—Control Group

(1) Ruptured Appendix. Died 50 hours of peritonitis.
(2) Ruptured Appendix. Died 68 hours of peritonitis.
(3) Supra-vaginal Hysterectomy. Died 5th day, peritonitis.
(4) Thoracotomy, bullet wound abdomen and chest. Died 3rd day, hæmothorax and peritonitis.
(5) Exploratory Laparotomy (peritonitis). Died 7th day, peritonitis.
(6) Pyelotomy. Died 5th day, 24 hours after second operation, anuria and uræmia (present before operation).
(7) Mid-thigh Amputation. Died 56 hours, acute toxæmia.
(8) Cholecystectomy and Appendicectomy. Died 56 hours from post-operative massive collapse of lung.
(9) Posterior Gastroenterostomy. Died 3rd day, cardiac failure.
(10) Cæsarean. Died 15th day, pulmonary embolus.
(11) Colostomy (carcinoma of sigmoid). Died 3 weeks, 6 days after second operation (cystotomy), cardiac failure.
(12) Pyelotomy. Died 6 months, œsophageal stricture.
(13) Diabetic osteomyelitis of foot. Died 3 months after incision and drainage of foot from multiple renal abscesses.

(14) Nephrectomy. Died 3 weeks, septicæmia with metastatic abscesses.
(15) Thoracotomy and Mastoidectomy. Died 4 weeks, septicæmia.
(16) Thyroidectomy. Died 29 hours, thyroid crisis.
(17) Thyroidectomy. Died 24 hours, thyroid crisis.
(18) Thyroidectomy (auricular fibrillation). Died 6 hours, cardiac failure.
(19) Nephrectomy. Died 36 hours, post-operative shock.
(20) Cholecystectomy and Appendicectomy. Died 29 hours, post-operative shock.
(21) Supra-vaginal Hysterectomy. Died 24 hours, post-operative shock.
(22) Supra-vaginal Hysterectomy. Died 2 hours, post-operative shock.
(23) Supra-vaginal Hysterectomy. Died during operation, "ether narcosis."
(24) Exploratory Laparotomy (aneurysm). Died 3rd day, anuria and uræmia (post-operative).

A summary in more detail is given below of the eleven deaths in the avertin group mentioned above. Incidentally, it is interesting to note that there happened to be in the control group of cases two deaths which could be said with fair certainty to be due to the anæsthesia—in each case, ether. One of these, a forty-four-old woman, died on the operating table with symptoms of over-etherization and without any signs of circulatory shock or other cause of death; post-mortem showed no cause of death other than ether narcosis. The second, a forty-five-year-old man, who took a poor ether anæsthetic—having a great deal of mucus and cyanosis all during the operation—developed signs of massive collapse of the lung and died fifty-six hours after operation.

In the summaries of these eleven deaths there are several instances of peculiar reactions and of unusual post-mortem findings which were not satisfactorily explained by the patients' disease or by the other findings at post-mortem examination. The question is, could these reactions and pathological changes have been produced by avertin? There are at least three ways in which this relatively "safe" drug might produce harmful effects, *i.e.*: (1) By overdosage; (2) by special susceptibility of a patient to some element of the "avertin fluid," and (3) through the formation in the body, under certain metabolic conditions, of a substance much more irritant and toxic than avertin itself.

Judging from the known physiological properties of avertin, the chief effects of overdosage would be prolonged coma, excessive circulatory depression, and to a less degree respiratory depression. Effects of this type were noted in several of the avertin cases. (Table VII.) None of these cases received doses of higher than 80 to 100 milligrams per kilo, but since the effect of the same dose in different patients varied widely it is quite probable that even the 80 to 100-milligram dose may have been a relative overdose for some patients, especially those weakened by age, shock, cachexia or poor cardiovascular function. The fact that a bromide rash appeared in one patient shows, also, that the possibility of hypersusceptibility to some portion of the avertin solution is more than hypothetical.

As regards the possibility of forming a secondary toxic substance, there would apparently be plenty of opportunity for such formation to occur dur-

ing the period (forty-eight hours plus) of retention of avertin in the body before its excretion. In the normal organism avertin is supposedly "detoxified" by entering very rapidly into a nonirritant combination with glycuronic acid in the liver. If, however, the metabolic or chemical conditions in the body were not suitable for the proper consummation of this protective combination with glycuronic acid—what then? The avertin might remain in the circulation unchanged (which is improbable), or it might be decomposed and form other, possibly more irritating, chemical combinations. It is known that *in vitro* avertin can be rather easily decomposed into such corrosive irritants as hydrobromic acid and di-brom-acet-aldehyde, and there are doubtless other potential decomposition products of similar toxicity. If these can be formed *in vitro*, there is no reason why similar irritants could not be produced in the body. As far as is known, all that stands in the way is a proper functioning of the glycuronic acid metabolism. Perhaps such toxic products in small amounts are formed more frequently than is suspected. If so, it would explain some of the transient, minor—and sometimes not so minor—toxic symptoms noted from time to time in the avertin patients in this group. It would also explain the "mild parenchymatous degeneration" of liver, kidneys and other organs which has been found in experimental animals after repeated administration of avertin.[5]

In discussing the eleven fatal cases in the avertin group these possibilities have been kept in mind. A brief summary and discussion of these eleven cases is given below.

Case I.—Forty-five-year-old man. Nephrectomy for pyelonephritis and renal calculus, 80-milligram dose of avertin supplemented by gas-oxygen and a very small amount of ether. After operation a paralytic ileus developed which failed to respond to treatment. Ileostomy performed on fifth day under local novocaine anæsthesia. Ileus unrelieved. Died thirty-six hours later in acute toxæmia with terminal cardiac exhaustion. Post-mortem showed usual signs of terminal cardiac failure but no peritonitis or other cause for the ileus.

What caused this very persistent ileus? Post-mortem examination showed no peritoneal infection and no organic obstruction. The patient was not uræmic. In the group of 431 avertin cases there were several instances of less marked paralytic ileus, apparently caused by the avertin anæsthetic. It is possible, therefore, that the ileus in this case might have been a post-avertin (toxic) effect—especially since it followed a nephrectomy, an operation in which kidney function—and hence avertin excretion—is more than usually disturbed.

Case II.—Forty-eight-year-old woman. Hepatico-duodenostomy for biliary fistula and atresia of the common duct, 80-milligram dose of avertin supplemented with gas-oxygen. Before operation patient was markedly cachetic and a poor operative risk. The operation was very difficult lasting three and one-half hours, during the last two hours of which the patient was in shock with imperceptible pulse. Remained in shock and died seven hours after operation without regaining consciousness. Post-mortem refused.

This death was definitely due to profound operative shock. The fact

that the patient did not regain consciousness before death seven hours after operation, however, suggests that the depressant effect of the avertin was much prolonged in the presence of the marked shock and cachexia. The 80-milligram dose which would be well within the margin of safety for an average person appeared to be an overdose for this patient. How much effect it may have had in depressing whatever slight rallying powers this patient had is problematical. The chief cause of death of course was very definitely the shock of the operation.

CASE III.—Fifty-nine-year-old woman. Exploratory laparotomy and cholecystotomy for fluid in abdomen, avertin supplemented by local anæsthesia. Patient was a very poor risk with a bad cardiac history and showed signs of considerable cardiac insufficiency at time of operation. After the avertin had been given the patient became quite cyanotic with marked respiratory and circulatory depression before any operative procedure was attempted. At operation gallons of ascitic fluid escaped and several large gall-stones which were pressing on the portal vein were removed. The patient was in shock during and after the operation and died two hours post-operatively still markedly cyanotic and depressed without regaining consciousness.

CASE IV.—Forty-five-year-old woman. Repair of massive incarcerated ventral hernia causing acute intestinal obstruction, 80-milligram dose of avertin with a small amount of gas-oxygen. Patient obese and toxic. Moderate shock with pulse of 130 at end of operation. Six hours later began to be very restless and cyanotic with signs of cardiac decompensation developing. Intravenous digitalization and glucose produced no improvement and the patient died ten hours after operation.

Both these cases were definitely deaths from cardiac failure precipitated by operative shock with no special incident to attract attention to the anæsthesia; although, as mentioned above, avertin, because of its depressant effect on the circulation, would not seem to be a good anæsthetic to use in the presence of poor cardiovascular function.

CASE V.—Seventy-five-year-old man. Orchidectomy and herniorraphy for right infected hydrocele and inguinal hernia, 100-milligram dose of avertin supplemented with gas-oxygen. Only a fair surgical risk having arteriosclerotic heart disease with considerable myocardial damage as shown by electro-cardiogram. Condition at end of operation was considered good, but subsequently could not be aroused from anæsthetic. In a few hours became cyanotic, showed signs of cardiac failure, and died eleven hours after operation without regaining consciousness. Post-mortem showed moderate arteriosclerosis of heart and kidneys, chronic emphysema, and a light, yellowish-brown liver showing signs of chronic degeneration. Pathologist's report: "The cause of death is not apparent at post-mortem."

This death might also be classified as a death from cardiac failure. But, as in Case II, the question arises, why did the patient not regain consciousness before death eleven hours after operation? If this profound coma were produced by the avertin what assurance is there that the rest of the post-operative picture with its fatal result was not also in large measure due to the anæsthetic? The chronic degeneration of the liver found at autopsy might indicate inability of the liver to carry out normal avertin detoxification. Arteriosclerotic degeneration of the kidneys was also present which may well have had a marked effect on avertin excretion.

CASE VI.—Eighty-two-year-old man. Mid-thigh amputation for arteriosclerotic gangrene of right foot, 80-milligram dose of avertin supplemented with gas-oxygen and a very small amount of ether. A rather poor surgical risk with arteriosclerotic heart disease and auricular fibrillation. Blood chemistry however was normal (urea 26, creatinin 1.9, sugar 96) and kidney function good (P.S.P. 60 per cent. in two hours). At end of operation went into shock from which he rallied quickly with treatment but continued drowsy, restless, and mentally confused. Twenty-four hours after operation his temperature rose sharply to over 103°, he became rapidly more toxic and died in coma twelve hours later. At this time the edges of the wound were foul, necrotic, and black with a moderate degree of gas crepitus. Post-operative urinary output was adequate—62 ounces in thirty-six hours. There seemed to be a slight degree of jaundice.

The clinical impression was that death was due to gas gangrene of the operative wound with secondary acute toxæmia. It was felt, however, that the rapid severe course of the toxæmia was out of proportion to the degree of infection, and the possibility of an added effect due to improperly detoxified avertin was considered. The slight jaundice suggested liver damage. Since post-mortem examination was refused there was no opportunity to check on these possibilities.

CASE VII.—Seventy-three-year-old woman. Sub-total thyroidectomy for enlarged thyroid with hyper-thyroidism, 80-milligram dose of avertin supplemented with gas-oxygen. Had a large nodular thyroid with considerable tracheal pressure symptoms, moderate hyperthyroidism, and auricular fibrillation. Operation was done after two weeks' rest in bed and one week of Lugol's solution with marked improvement. A moderate thyrotoxic reaction occurred during the first twenty-four hours after operation which became rapidly more severe during the second day. Died forty hours post-operatively from cardiac failure with a terminal temperature of 107.4°. Post-mortem showed chronic myocardial degeneration, pulmonary œdema, and œdema with small hæmorrhagic areas in the mediastinum.

CASE VIII.—Fourteen-year-old girl. Sub-total thyroidectomy for Graves' disease, avertin, with gas-oxygen. Pre-operative condition did not improve with rest in bed and medication with Lugol's solution. Operation done two weeks after admission to hospital. Twelve hours after operation developed signs of massive collapse of right lung with marked displacement of heart and mediastinum, causing obstruction of venous return. Right pneumothorax, produced artificially, gave some relief but, although respirations were easier, temperature and pulse continued to rise and patient died forty-six hours after operation with symptoms of marked acute thyrotoxic reaction and terminal cardiac failure.

Death in both these cases was definitely due to post-operative thyroid reactions, complicated in one case by severe heart disease and in the other by post-operative massive collapse of the right lung. There was no suggestion that the anæsthesia had anything to do with either of these fatalities.

CASE IX.—Thirty-seven-year-old woman. Sub-total thyroidectomy for Graves' disease, 100-milligram dose of avertin supplemented with gas-oxygen and ether mixture. Operated on after nine days in the hospital. During operation had a lot of mucus in throat, necessitating use of suction. Was cyanotic with much mucus in throat on return to bed but condition otherwise good. Developed a moderate thyrotoxic reaction; also started to cough a few hours after operation. Day after operation cough increased and T.P.R. began to rise higher. Thirty-six hours post-operative became very lethargic, difficult to arouse, urinary output decreased—7 ounces first twelve hours post-operatively, 6 ounces next twenty-four hours, and ½ ounce next twelve hours (catheterized). In

spite of glucose infusions, clyses, fluids forced by mouth, and diuretic medication (diuretin), she sank deeper into coma, respirations became labored, and circulation weaker. Died in coma forty-six hours after operation. Post-mortem showed a confluent lobular pneumonia, marked acute tubular degeneration of the kidney, very extensive acute degenerative and hæmorrhagic necrosis of the liver, areas of focal necrosis in the myocardium, and a large persistent thymus.

The post-mortem changes found in this case—extensive acute necrosis in liver, kidneys, heart, and lungs—can only be explained as due to the action of some potent corrosive irritant. In view of the clinical history this irritant must have been introduced into the body at the time of, or shortly after, operation. It seems almost certain that the source of this toxic irritant in this patient must have been the avertin anæsthetic. It seems especially significant that the post-mortem findings in this case were almost identical with post-mortem changes reported recently by Hare and Wright[8] in describing a fatal case following avertin narcosis in a cat. The cat described reacted normally for the first few hours after operation, as did this patient, and died in about twenty hours, post-mortem showing generalized acute necrosis of the liver, acute degeneration of the kidneys, diffuse œdema of the lungs with a patch of acute bronchopneumonia, and subendocardial hæmorrhages.

CASE X.—Twenty-seven-year-old woman. Sub-total thyroidectomy for Graves' disease, 100 milligrams dose of avertin supplemented with gas-oxygen. A moderately toxic colored woman admitted with a basal metabolism of plus 20 which jumped to plus 32 after about a week's rest in bed. After two and one-half weeks' rest in bed and ten days medication with Lugol's solution, she seemed in good condition for operation. Fifteen minutes after start of operation, pulse rose suddenly from 100 to 160 then fell to 140. The operation was continued with the pulse ranging from 150 to 170, bounding quality, respirations rapid. Condition poor at end of operation. One hour later pulse became imperceptible and lungs filled up with œdema. Patient died with symptoms of acute cardiac failure and pulmonary œdema one and one-half hours after operation with rectal temperature of 102½°. Post-mortem showed marked acute pulmonary œdema with considerable fresh pleural, effusion, very marked acute congestion of all the viscera (noted to be much more than usual post-mortem congestion), sub-endocardial hæmorrhages in the heart, and a large, persistent thymus.

The sudden acute cardiac failure and pulmonary œdema in this case may have been part of a fulminating thyroid reaction. The points against such an interpretation are: (1) This was not the type of thyroid case in which such reactions usually occur—the patient was not severely thyrotoxic and had had thorough pre-operative treatment with rest, sedatives, and Lugol's solution; (2) the circulatory breakdown started very early in the operation when there had been little operative shock or trauma to the thyroid gland, and (3) the patients pre-operative cardiac status was excellent as demonstrated by medical consultation and electro-cardiographic study.

The severity and the unexpectedness of the fatal reaction in this case suggested that some unusual factor was involved and, having only a few hours before viewed the post-mortem on Case IX, suspicion was naturally directed toward the avertin anæsthesia. In a hypersusceptible patient avertin might

readily cause sufficiently marked depression of the circulation to have caused the sequence of events causing this death. It was suggested that the unusual degree of visceral congestion and the subendocardial hæmorrhages might represent the earliest stages of an acute necrotic process similar to that found at post-mortem in Case IX.

Since patients IX and X both died on the same day, the possibility of the stock solution of avertin having deteriorated was considered but the solution was checked on many other cases both before and after without any ill-effects being observed. The persistent thymus in both cases was believed not to be significant except as a glandular condition associated with the thyrotoxic state. Neither death was of the thymic type.

CASE XI.—Thirty-three-year-old woman. Vaginal repair with interposition and sterilization, 100-milligrams dose of avertin supplemented with gas-oxygen and ether mixture. Patient appeared to be a normal, healthy young woman before operation and her condition during and at the end of the operation was good. Two hours later she appeared to be in some shock and was very restless, talkative, and mentally confused. Her color was a peculiar combination of pallor and cyanosis. She continued very restless and developed a marked psychosis. There were no signs of intraperitoneal hæmorrhage or infection. The severity of her symptoms was slightly relieved for short intervals by intravenous infusions and by a transfusion, but in spite of all treatment temperature and pulse gradually rose with associated weakening of the circulation and she died in semi-coma and circulatory collapse thirty hours after operation, with a terminal temperature of 106.4° and pulse of 170. The respirations remained normal and there were no signs of pulmonary pathology. Only 3 ounces of urine (catheterized) were obtained in thirty hours in spite of several infusions, a large clysis, and a transfusion.

The cause of death in this case was obscure. There were no signs of peritoneal hæmorrhage or infection, or of pulmonary embolism. The process was too fulminating to be a purely uræmic death secondary to kidney shut-down. There was no evidence of hyperthyroidism.

There was obviously a severe degree of toxæmia and shock which affected especially the kidneys and cardiovascular system and which was not relieved by the usual therapy. The only origin for this toxæmia which could not be ruled out with fair certainty was the avertin anæsthesia. Unfortunately, post-mortem examination was refused so that the pathology back of this patient's symptoms could not be determined.

In two or three of these eleven cases, therefore, it seems quite possible—in Case IX quite probable—that the avertin was at least partly responsible for the fatal outcome. In several of the other cases there were indications that the avertin had had some adverse effect which may or may not have contributed considerably to the fatality. The evidence of the guilt of avertin is not in any of the cases completely convincing, but it is suggestive enough to strengthen the feeling that avertin is not quite as safe and completely harmless an anæsthetic as many of its proponents believe, and that it should be used with caution until more is known about the chemical and physiological properties of the various decomposition products and chemical combinations which may be produced by it in the body under varying conditions.

Summary.—A study was made of 431 surgical cases which were given avertin anæsthesia over an eighteen-month period at the Brooklyn Hospital. These cases were compared with 431 similar surgical cases given other types of anæsthesia at the same hospital.

The preparation of avertin used was "Avertin Fluid" (Winthrop), a composite drug containing tri-brom-ethyl-alcohol (avertin) and amylene hydrate in solution. In most of the cases the aim was to use this solution as a basal anæsthetic only—that is, to produce unconsciousness and amnesia during the pre-operative and operative period without necessarily producing complete pain insensibility or muscular relaxation. Morphine and atropine were usually given by hypodermic before the avertin, producing a smoother basal anæsthesia without noticeable harmful effect.

Doses varying from 60 milligrams per kilo to 100 milligrams per kilo were used. The larger doses produced unconsciousness more rapidly and for a longer time than the smaller doses, and required less supplementary anæsthesia, especially ether. On the other hand, the larger doses occasionally produced symptoms of overdosage such as excessive circulatory depression or prolonged coma, especially in patients weakened by chronic illness, age, cachexia, shock, *etc.* In addition, in some cases, various toxic reactions were noted post-operatively which it was difficult to explain except as sequelæ of the avertin anæsthetic. In several cases symptoms of overdosage or unusual toxic manifestations were followed in a few hours by death. One of these cases showed at post-mortem extensive acute necrosis of liver, kidneys, heart and lungs evidently caused by a strong corrosive irritant for which no source could be determined other than the avertin which had been administered for basal anæsthesia in dosage of 100 milligrams per kilo.

The immediate post-operative course was in general more pleasant from the patients point of view, but the need for special nursing care was increased because of the irresponsibility of the patients during the long period of awakening from the anæsthesia. Post-operative vomiting and to a less degree post-operative respiratory complications were decreased in the avertin patients. This decrease appeared to be largely attributable to the decreased amount of ether used when avertin was given.

The effect on kidney function following kidney operations performed with avertin basal anæsthesia was investigated. The usual marked decrease in output during the first two or three days post-operative was found but this was not more marked than the decrease in output in the control cases which had similar operations.

The possibility of a good or bad effect of avertin on thyroid reactions following thyroidectomy was considered but no difference was found between the severity of reactions in the avertin and the control cases. With avertin, however, pre-operative apprehension and excitement were entirely abolished and the patient could be kept unaware of the time of operation, if desired.

ADVANTAGES AND DISADVANTAGES

As a result of these findings we would list the advantages and disadvantages of avertin as follows:

ADVANTAGES.—*Pre-operative.*—(1) Can be administered in bed without discomfort. Induction resembles natural sleep.

(2) In cases of hyperthyroidism, emotional instability, *etc.*, pre-operative excitement can be abolished by having patients' nurse give the avertin as if it were an ordinary enema.

Operative.—(1) When supplemented with gas-oxygen, satisfactory anæsthesia and muscular relaxation can often be obtained for many major surgical operations which usually require deep ether anæsthesia, including laparotomies and orthopædic manipulations.

(2) When ether is needed in addition to the gas-oxygen, the amount required is markedly reduced.

Post-operative.—(1) Amnesia is usually produced covering the operative and early part of the post-operative period.

(2) Immediate post-operative distress is in many cases considerably decreased due to (*a*) prolonged drowsiness; (*b*) decreased vomiting; (*c*) decreased respiratory irritation; (*d*) decreased "ether taste."

DISADVANTAGES.—*Pre-operative.*—(1) Solution must be freshly prepared for each case and carefully tested for proper temperature and acidity.

(2) When once administered, dosage cannot be decreased because of rapidity of absorption.

(3) Length and variability of induction period may delay the operating schedule.

Operative.—(1) Depth of anæsthesia with a given dose is uncertain and variable. For this reason cannot be satisfactorily used to avoid the use of ether (as when electrocautery is used for head or chest operations, *etc.*).

(2) Is unsatisfactory when used with local or regional anæsthesia because patient is uncoöperative while retaining power of motion and speech.

(3) Anæsthesia cannot be lightened if patient's tolerance decreases, as in the event of serious hæmorrhage or operative shock.

Post-operative.—(1) Prolonged post-operative special nursing is required because of long period of semi-coma and irrational restlessness.

(2) Excretion is slow and is almost solely through the kidneys. Kidney output is frequently diminished markedly after operation, making excretion even slower.

(3) The wide variation in susceptibility to avertin and narrow margin between the therapeutic and the toxic dose results in the occasional occurrence of toxic symptoms, and even death, after moderate doses (100 milligrams per kilo or less).

Conclusions.—We feel, after studying these 431 cases of avertin administration and the 431 controls, that "Avertin Fluid" used as a basal anæsthetic in combination with gas-oxygen or gas-oxygen and ether has some advantages not possessed by most other anæsthetics and that accordingly it has a distinctly useful place in the roll of anæsthetics. There are, on the other hand, several definite disadvantages which must be considered in selecting avertin for any given case.

The occurrence of toxic and overdosage symptoms in several of our cases, with at least one fatality, after the administration of doses of 100 or 80 milligrams per kilo, indicates to us that this dosage is not entirely safe for routine use. We feel that the 80-milligram and 100-milligram doses have no important advantage over the 60 to 70-milligram dose and are considerably

more dangerous. The 60 to 70-milligram dose, especially when combined with a pre-operative hypodermic of morphine, usually produces the essentials of a basal anæsthesia. When this is inadequate, there is no objection to giving a small additional dose of avertin after the effect of the initial dose has been fully observed.

The occasional production of complete anæsthesia by the larger doses is, we believe, by no means an advantage, indicating rather an overdose with the associated greater risk. We feel, also, that any slight increase in the patient's comfort which may follow the use of larger doses is greatly outweighed by the increased liability to overdosage and to toxic reactions. We would prefer to use avertin only to obtain the minimal satisfactory basal anæsthesia and to complete the anæsthesia with gas-oxygen or, when necessary, ether. More ether seems safer than more avertin.

We consider certain conditions to be absolute contra-indications to the use of avertin—at least until more is known about the chemistry of detoxification and excretion of avertin in the body. In the presence of any of these contra-indications we would not consider even the 60-milligram dose safe to use.

Foremost among contra-indications we would place any condition lowering liver function. This would include not only intrinsic pathology of the liver and its ducts, but also circulatory insufficiency with consequent liver congestion and any condition associated with marked depletion of glycogen. Any evidence of decreased kidney function should be considered of almost equal importance as a contra-indication. This means not only evidence of decreased function before operation as demonstrated by urine and blood tests, but also the probability of function being decreased more than usual following operation due to such causes as trauma to the urinary tract, post-operative shock, post-operative dehydration, *etc.* A review of the fatal cases discussed above shows that in many of them there was evidence of impaired liver or kidney function and in some of them, primary disease of these organs.

As other contra-indications we would include:

(1) Severe cardiac disease—because of the depressant effect of avertin on the circulation and because of the congestion of liver and kidneys associated with poor cardiac function.

(2) Old age—because old people are often hypersusceptible to avertin and because of senile and arteriosclerotic changes usually present in liver and kidneys.

(3) Cachexia—because of the probability of lowered tolerance for all drugs, including avertin, and because of the usually poor glycogen metabolism.

(4) Marked shock or dehydration—primarily because of effect on kidney function.

(5) Marked acidosis or acute toxæmia—because of disturbance of body chemistry and metabolism which may have a harmful effect on avertin detoxification. It is a question if severe thyrotoxicosis should not also be included in this group.

By adhering to these contra-indications and by using the 60 to 70-milligram dose rather than the larger doses, we feel that in the future we may prevent many undesirable reactions and avoid any avertin fatalities.

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TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

STATED MEETING HELD MAY 11, 1932

The President, Dr. John Douglas, in the Chair

FIBROMA OF THE STOMACH

Dr. Robert H. Kennedy presented a woman, aged sixty-three, who was admitted to Stuyvesant Square Hospital June 19, 1930, complaining of belching of gas and vomiting. There was no history of cancer in her family. Seventeen years previously a tumor had been removed from the hip region, nature unknown. Her past history was otherwise irrelevant.

For two years before admission she had had a sour taste in her mouth with belching of considerable gas after eating. She felt that she could not eat much at a time and had not eaten meat for the past six months. About six months before admission she consulted a physician for the first time. For several months past she had vomited frequently immediately after eating. She had never had any pain and had lost but four pounds in weight. She was in fairly good general condition with no palpable abdominal masses nor tenderness. The X-ray following a barium meal showed an obstruction to the passage of barium apparently 1 inch to the left of the spinal column with marked six-hour retention and some twenty-four-hour retention. There was no filling defect seen in any picture nor in the fluoroscopic examination. Gastric analysis showed no free hydrochloric acid present and a total acidity of forty-six. The benzidine test was positive and no lactic acid was found.

Operation June 25, 1930, under colonic ether. Median upper abdominal incision. Nothing was felt in the anterior wall of the stomach. A movable mass was felt posteriorly 2½ by 1 inches in diameter. The distal margin extended to within 3 inches of the pylorus. A 2-inch vertical incision was made through the anterior wall of the stomach about midway between the lesser and greater curvatures. The tumor was freely movable beneath the mucous membrane of the posterior wall. There was no pedicle. A 1½-inch incision was made through the mucous membrane of the posterior wall over the mass which was dissected out bluntly. It lay between the mucosa and serosa near the greater curvature. Its consistency was that of a uterine fibroid, well encapsulated and divided into three lobules. It had evidently acted as a ball valve, even though there was not a pedicle. The mucous membrane was sutured with continuous chromic gut. The anterior wall of the stomach was closed by two layers of sutures and a tab of omentum was sutured over this line. The patient made an uneventful post-operative recovery.

Microscopical examination showed interlacing bundles of fibroblasts with œdema. It is now twenty-two months since operation. The patient has no complaints and is on a regular diet.

According to Lockwood nearly a thousand cases of benign tumor of the stomach have been reported. The incidence varies from 1 to 5 per cent. of all

growths of the stomach. Single tumors predominate and the majority are less than 1 inch in diameter.

CONGENITAL FISTULA OF THE NOSE

DOCTOR KENNEDY presented a boy, three years of age, who was admitted to the Stuyvesant Square Hospital February 5, 1932, on account of a discharging area on the right side of the nose near the root. His mother stated that about a year and a half previously she noticed a pimple on the right side of his nose. In a short time this opened, discharged a small amount of pus and then scabbed over. This process was repeated several times. The patient was said to have had a "running nose" from birth. The father and mother were healthy and no abnormalities known of in them, their relatives, nor their one older child.

FIG. 1.

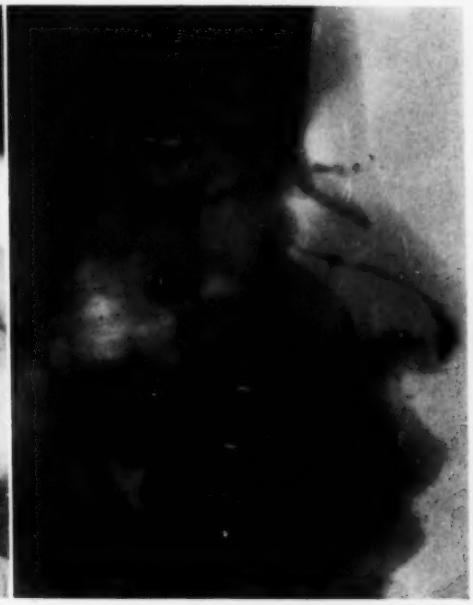

FIG. 2.

FIG. 1.—Congenital fistula of the nose. Note the upper opening on right side of the base of the nose; the lower opening on the under surface of the tip of the nose. The lower opening, the size of a pin point, has been emphasized by a ring of ink to mark its location.
FIG. 2.—X-ray photograph of lipiodol injection of congenital fistula of the nose. Note depth beneath the nasal bone.

Examination showed a healthy child with a scabbed-over area on the right side of the nose 1 centimetre in diameter. This was slightly raised above the surface and had no reaction about it. There was no discharge at this time. It suggested an infected granuloma, possibly from a foreign body. The testicles were not found in either inguinal canal nor in the scrotum. A dimple was present over the apex of the sacrum, but no opening was made out. Otherwise no abnormalities were found.

The scab was removed and an attempt made to inject methylene blue through a small opening beneath. It seemed to hold practically nothing. A probe could be inserted mesially and upward for a distance of 1.5 centimetres. The cavity was entirely surrounded by bone. It seemed probable that ethmoid cells had been entered. However, a swab inserted in the right

nostril failed to show any methylene blue, but on withdrawing this the pressure on the nostril caused a minute bead of blue color to appear on the under surface of the tip of the nose in the median line. The opening was pin point in size.

X-rays taken after injection of lipiodol in the upper opening showed a tract extending mesially and slightly upward, then downward in the median line to the tip of the nose. The middle portion of the tract appeared to be at a depth which would place it just under the mucous membrane of the nose. The accessory sinuses were negative. It seemed that it might be possible to excise each end of the tract through skin incisions and the middle portion through the inside of the nasal cavity. (Figs. 1 and 2.)

February 11, 1932, under colonic avertin anæsthesia, supplemented with ether, the tract was excised. Methylene blue was first injected into the upper opening. Attempts to introduce fine metal probes into the lower opening were not successful beyond 1 inch. A ureteral filiform was then inserted for over 2 inches. It could not be felt through the upper opening, nor through the mucous membrane of the nose. Therefore, an incision was made in the median line for practically the entire length of the dorsum of the nose and encircling the lower opening. The tract passed upward superficially for a short distance to what was apparently the junction of the medial crura of the greater alar cartilages with the cartilage of the septum. Here it dipped into the septum. The septal cartilage was incised from this point upward to the nasal bones and these were cut through in the medial line for about 1 centimetre with chisel and hammer. It was then evident that the tract lay in a canal completely surrounded by cartilage or bone throughout its extent, *i.e.*, between the walls of an incompletely united septum. With the filiform in place, it was possible by sharp dissection to separate the tract from its surrounding cartilage and bone up to its upper expansion. This portion, on removal, measured 6 centimetres in length. The upper opening was then excised with the tissue surrounding the opening into bone. This opening was about 5 millimetres in diameter. On enlarging it, a cavity in bone was found beneath, 1.5 centimetres in diameter, with a very thin lining. The fistulous tract entered this at such a sharp angle that it was impossible to push the filiform up into this space, even though its point could be seen. This upper expanded portion was simply curetted. Both wounds were closed without drainage. At no time during the operation was there any suggestion of blood within the nose. The boy was discharged on the seventh day post-operative with both wounds healed.

Microscopical examination of the tract showed a lining of epidermis with underlying skin structure and hair follicles. No hair was found lying in the fistula.

From the material published on congenital fistula of the nose or dermoid cysts of the nose, this would seem to be a rare condition. In 1912 Oyez, of Lille, reports in detail on thirty cases which he found in the literature and added two of his own. The earliest reference found was by Lawrence, who reported two cases in 1837. Hart, in a later report, was able to find eight other cases before 1912. Eight authors have written on this subject since 1912: three German, three Dutch, one Italian and one American. Six of these articles report nine cases. This makes a total of forty-nine cases which the reporter had been able to find previously reported.

Among the patients cited by Oyez, the fistula in one of Bramann's cases admitted a probe from the junction of the cartilage and the nasal bones to the base of the nose, but the tract was not excised. Cruvielhier had a similar case which was not operated on. Two others passed deeply into the bone but not over half an inch in length. In seven other instances it is mentioned that the tract was densely adherent to bone and one wonders if in some it did not pass more deeply but was unrecognized with the facilities at hand. Of the more recent cases, all the tracts seem to have been quite short except in one reported by Vermeulen and one by Trampnau. Both of these had lipiodol injections and are quite similar in extent to the case reported here. Trampnau's case had a tract 4 centimetres long. Hart in 1927 reported the only case which has been published in the United States. This showed a tract running the length of the nasal bone, but no bone involvement was demonstrated.

It is possible that these cases may be more common than the number of reports shows. With lipiodol injections it is probable that more of the tracts will be found running deeply in cartilage or bone. With the possible exception of Vermeulen's patient, the tract in the case presented is the longest on record, 7.5 centimetres.

J. Bland Sutton gives the following explanation of the origin of this abnormality:

> In the early embryo, the rudiment of the nose is represented by that process of the primitive skull which is known as the fronto-nasal plate. This is separated from the lateral portions of the face by the orbito-nasal fissures. The rounded angles of the fronto-nasal plate are known as globular processes. Each process forms a portion of the ala of a nostril and the corresponding premaxilla. These processes fuse in the middle line and give rise to the central medium piece (philtrum) of the upper lip. Dermoids of the nose are invariably situated in the line of the internasal groove and are in all probability due to incomplete fusion of the globular processes.

TRANSPLANTATION OF BILIARY FISTULA INTO STOMACH

Dr. W. Howard Barber presented a man, thirty-four years of age, who entered Bellevue Hospital September 30, 1931. He was in a wretched physical condition, reduced to 105 pounds in weight. He had had a cholecystectomy and appendectomy performed in another hospital in July and since that time had persistently drained bile from the upper extremity of the wound. Stools had been a light yellow. Had suffered from diarrhœa, having eight to ten watery stools a day. Anorexia and gaseous eructations were other digestive symptoms complained of. He presented an upper 8-inch right rectus scar with a biliary fistula at its upper extremity. Blood showed a slight secondary anæmia and a negative Wassermann. Urine negative. Van den Bergh direct and indirect negative. X-ray examination revealed a dilated stomach adherent to the right with a 75 per cent. retention at end of six hours. Lipiodol injection revealed dye in bile-ducts. At operation under spinal anæsthesia, October 14, 1932, a fistulous tract was found adherent to liver, stomach, and great omentum. (Figs. 3 and 4.) No stone was palpated nor was it possible to determine the pathological condition of the ducts. The

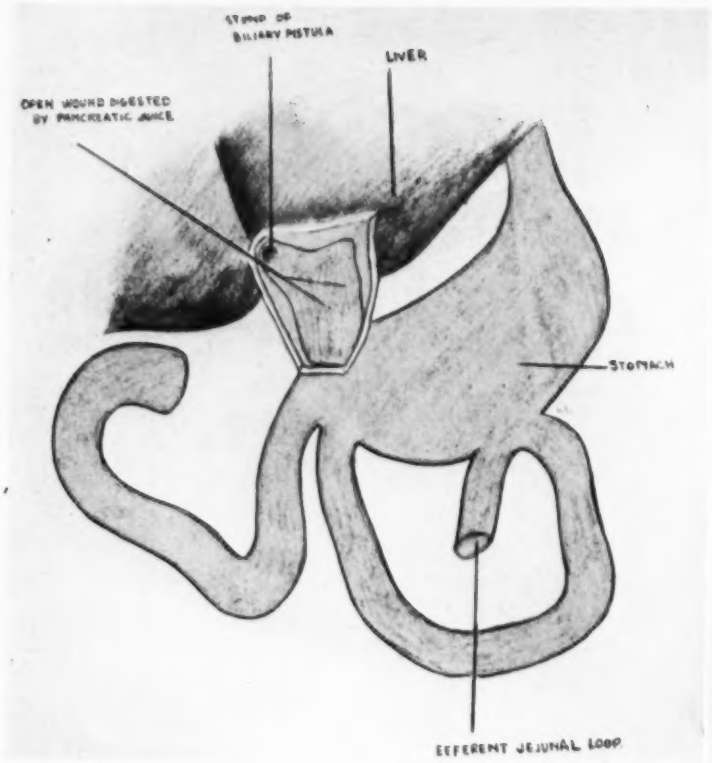

FIG. 3.—Semidiagrammatic post-mortem drawing illustrating condition of patient with biliary fistula upon admission to Hospital. Failure followed attempted transplantation of fistula into duodenum.

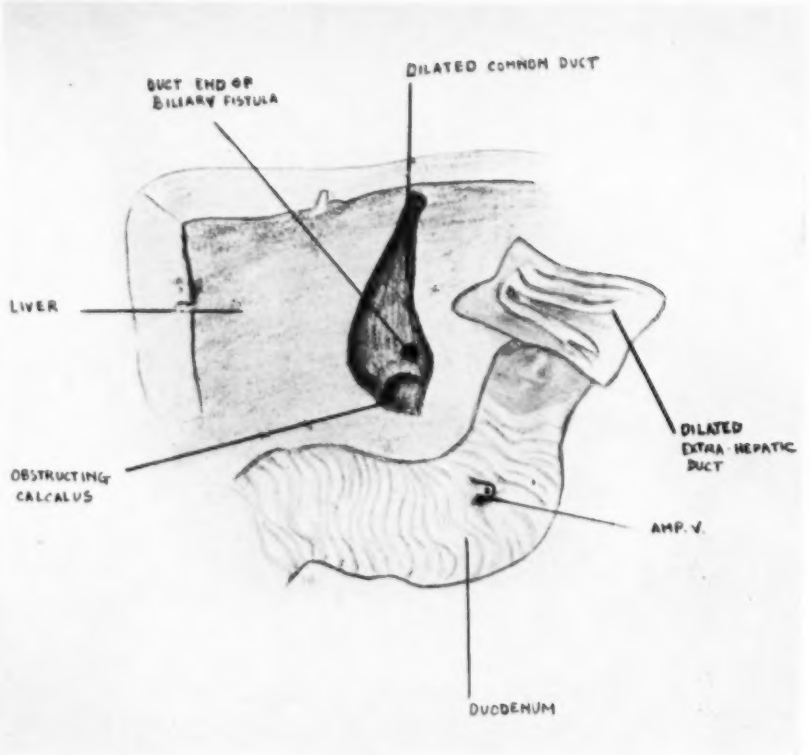

FIG. 4.—Drawing of same patient disclosing obstructing stone in common duct not discoverable at operation and only after a prolonged search post-mortem.

gall-bladder was absent. The fistulous tract with a plaque of skin was dissected down to the liver and sutured within the antral portion of the stomach through a vertical incision similar to the technic described before this Society, published in the ANNALS OF SURGERY, vol. xcv, pp. 263–268. Microscopical examination of tissue removed from about the fistula showed chronic inflammation. He discharged small amount of bile the first few days and ran a temperature of 100 to 105° during the first six days. Thereafter to the twenty-ninth day the temperature ranged from 100 to 102.6°. It became normal on the twenty-ninth and he was discharged to the outpatient department on the thirty-third day. During the last week of hospital residence, the wound healed, and he gained 3 pounds in weight. His appetite improved, the gaseous eructations improved, his bowel movements have become normal so that he had a movement a day without cathartics, and weight has increased to present amount of 155 pounds.

The restoration of bile to the stomach appears to have improved his gastric function and bowel elimination. The seepage of a small amount of bile after these anastomoses is thought to be consistent with the changes going on about the fistulous neck within the grasp of the stomach wound during the first few days. It is believed helpful to keep the stomach empty and at rest during this interval. The arrangement seems to be as normal and still as direct and simple as possible in a poor-risk case after cholecystectomy, with obstructed common duct completely obscured in adhesions.

It is thought that a reparative operation upon the bile-ducts to be safe and permanent should be carried out as in the above technic without an indwelling catheter and should be entirely free from any tension upon the anastomosis. The skin flap admirably serves to fix the tract while healing occurs within the stomach wall. The making of this flap a little larger than the opening in the stomach of itself prevents retraction. In this procedure the adhesions have been taken advantage of inasmuch as they have already arrested the stomach in a position most favorable for bile fistula implantation.

Doctor Barber, in conclusion, declared that given a persistent biliary fistula it was the practice to determine from a study of the history and all procurable data the most probable cause of the duct obstruction. If the condition appears to be due to an incompletely removed gall-bladder with stones and the operable field is not too obscured with adhesions, the indication is clear for cholecystectomy but if the condition is not clearly indicated by the data at hand and the operability of the cause of the obstruction remains in doubt, the fistula is dissected out to the liver border and held in reserve while the ducts are explored. Should exploration be impossible or should the cause of the obstruction be an irremovable growth or stricture, transplantation is carried out and the wound closed about a drain.

He reported a case of the latter type jaundiced notwithstanding complete external fistula with profuse drainage, emaciated, asthenic, prematurely senile, with a leucopenia that did not respond to repeated transfusions, adhesions following two gastroenterostomies and a cholecystectomy making exploration impossible. See Figs. 3 and 4. Transplantation into the oral duodenal loop was attempted, held for two days, but sloughed out apparently because of the extreme lowered resistance and physical reserve of the patient. He showed drawings of this case illustrating a common-duct stone which required one hour's post-mortem dissection to expose, dilated extrahepatic ducts, and a yellow atrophic liver. There had been, perhaps, six of the former category and three of the latter in the past four to five years. Of the latter two both of whom have been shown before this Society were successful and the one illustrated above, hopeless from the beginning, was unimproved.

DIVERTICULOSIS WITH EXTRUSION OF FECOLITHS INTO OMENTA

DOCTOR BARBER presented a woman, forty-one years of age, who was admitted to Bellevue Hospital February 5, 1932. She gave a history of increasing fatigue during her housework since November, 1931. She complained of nausea and vomiting coming on immediately after meals. She had neither hæmatemesis nor tarry stools but had noticed bright blood in her bowel evacuations. There was neither rigidity nor tenderness in the abdomen but the liver descended two fingers below the costal border; spleen was enlarged and ascites present. January 23, 1932, the X-ray department reported numerous diverticula throughout cæcum, ascending and descending colon. Duodenal cap fixed in region of gall-bladder; normal œsophagus and stomach. Gastric analysis showed low total and absent free hydrochloric. Stool examination showed considerable neutral fat. Urine, negative. The blood showed 3,370,000 red cells; 50 to 60 per cent. hæmoglobin; 8,000 leucocytes and 76 polymorphonuclears. Wassermann, both blood and spinal, negative. Van den Bergh direct, delayed; and indirect, positive. Icteric index plus 9–20. Non-protein nitrogen, 32. Sugar, 110. Creatinin, 1.6. A tentative diagnosis of cholecystitis was made together with cirrhosis and diverticulosis.

FIG. 5.—Drawing depicting extreme diverticulosis of colon in cirrhotic adult female patient. Many of the diverticula had ruptured setting the concretions free in the omentum. There was total absence of reactionary inflammation at sites of rupture in the colon or at the sites of lodgement in the omental fat. Cf. experimental drawings, Figs. 8 and 9.

Patient was operated on February 10, 1932. At operation, right lobe of liver was found enlarged and hard; gall-bladder was free, slightly thickened but emptied under pressure; there were no stones and no adhesions; pancreas was moderately thickened. There was considerable free sanguinous fluid in the peritoneum. The outstanding finding, however, was the multiple concretions studding the great omentum (Fig. 5) bordering upon the ascending, transverse and descending colon. The concretions were found within the diverticula observed on the röntgenograms. Many of these concretions approximated 3 centimetres in diameter, but most of them 1 centimetre. One was removed from the hepatic flexure region of omentum and one from the sigmoid colon together with the diverticulum. Abdomen was closed without drainage.

The microscopical report dated, February 16, 1932, was as follows:

Specimen consists of two irregular-shaped masses of material, one specimen is about 1 centimetre in diameter, very friable, dark brown in color and resembles a fæcolith. On section it cuts with marked ease; shows a dark brown centre with a lighter brown periphery. The second piece is grayish on section. Microscopically the tissue (Fig. 6) is that from the large intestine with round-cell infiltration and small connective-tissue deposit. The fæcolith (Fig. 7) shows the usual structureless material with golden yellow bile pigment and nondescript material.

The woman has since returned for treatment of cardiac decompensation. The abdominal condition has remained practically symptomless.

The interesting feature in this case is the occurrence of repeated slow perforations of diverticula by fæcoliths without the production of symptoms of diverticulitis and without observable inflammatory reaction in the omental fat or adjacent borders of colon. Apparently, the colonic wall overlying the fæcolith thinned out and gave way as the neck of the diverticulum closed in, thus allowing the escape of calcified fæcoliths without contamination from the bowel.

An attempt was made to reproduce experimentally the passage of foreign

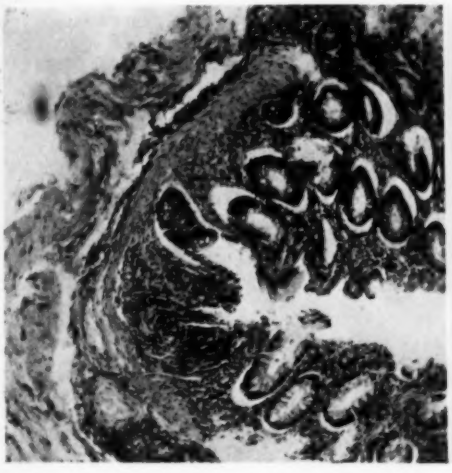

FIG. 6.—Low-power microphotograph of wall of diverticulum from the colon. Note the thin muscular coat.

FIG. 7.—Low-power microphotograph of a section through a fæcolith taken from the omentum.

bodies from diverticula-like pouches of sigmoidal wall, and is represented on accompanying drawings. Four glass beads (Figs. 8 and 9) 1 centimetre in diameter, were drawn out from within the wall of the bowel, two at the mesosigmoidal border and two at the antimesenteric border, and ligated with linen as shown in illustrations. Omentum was sutured about the segment containing the beads. Nine days later the beads had perforated the bowel, one suture had invaginated and remained attached at margin of healed perforation, the remaining three had evaginated and were found buried in nodules of dense fibrous tissue; and small intestine and urinary bladder, in addition to omentum, were firmly adherent at sites of perforation. There was no evidence of peritonitis. The dog was in good condition when submitted to euthanasia.

The similarity in the clinical and experimental findings is that perforation proceeded without peritonitis but the striking difference is the absence of inflammatory reactions after several perforations in the clinical case and the marked fibrous tissue production in and about the experimental perforations.

Drawings representing technic of ligating beads in diverticula-like pouches in canine colon.

Omentum sutured over "diverticula."

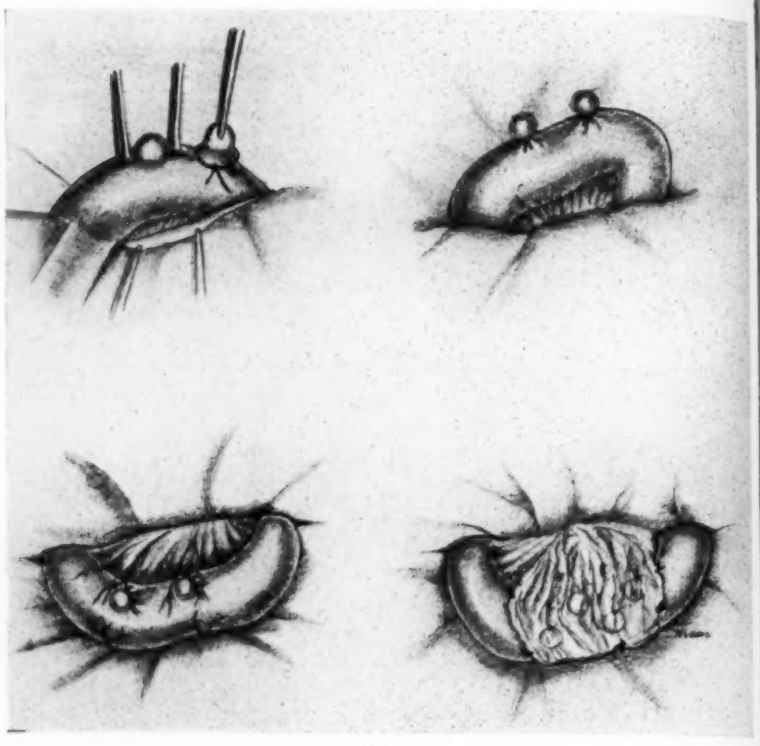

FIG. 8.

Mucosal surface of colon nine days later. Note healed perforations.

Serosal surface with attached omentum. Note nodules of dense fibrous tissue about sites of rupture of foreign bodies. Cf. Fig. 5.

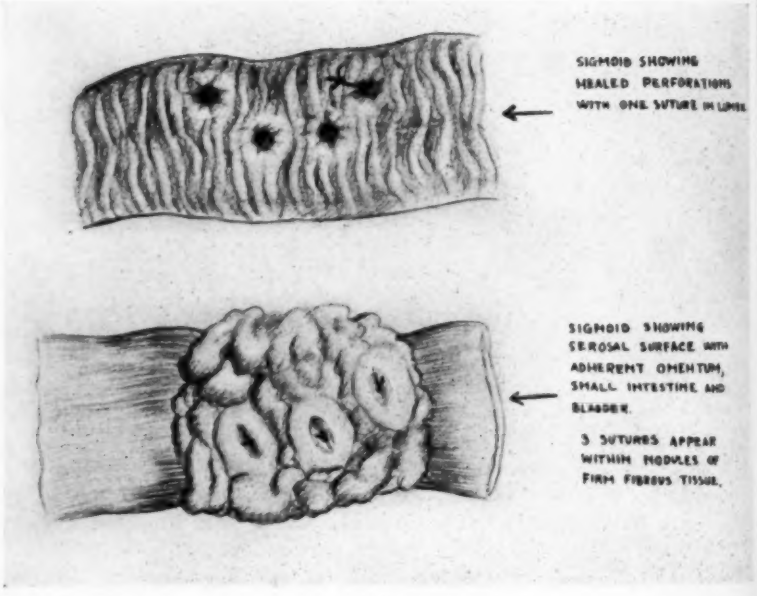

FIG. 9.

This latter observation is believed to be more in keeping with clinical experience.

DR. CARL EGGERS said that in diverticulosis of the colon some of the patients present an alarming clinical picture, with symptoms of intestinal obstruction, but half of them will recover without surgical interference. The majority who come in for surgery come for an acute emergency. All patients who have diverticulosis are liable to develop diverticulitis with its high mortality. Therefore they should be advised to keep the bowels open and adhere to a light diet with little residue. The disease should be looked upon as a serious condition.

COMMINUTED SPIRAL FRACTURE OF THE FEMUR WITH OPEN REDUCTION

DR. DONALD GORDON presented a woman, thirty-seven years of age, who while walking on the street on April 10, 1929, was struck by a motor car. She was taken to a nearby hospital where X-ray showed comminuted fracture of middle third of left femur with displacement, and a reduced fracture of right ankle. There were multiple contusions of face. The patient's employer had her transferred to the Fifth Avenue Hospital, where an immediate X-ray showed the left femur to have a comminuted spiral fracture of the shaft just below the middle, with one fairly large detached fragment from the inner and posterior portion of the shaft. There was very slight overriding and the alignment was fair. The right ankle showed a Pott's fracture with posterior dislocation of tarsus, a fragment off posterior surface of the inferior articular surface of tibia.

April 11, 1929, under general anæsthesia, the fracture of the right ankle was reduced with the patient in bed, and a non-padded split plaster encasement was applied from toes to mid-thigh. Röntgenogram of right ankle after reduction showed fragments in good position. The left femur showed greater displacement, proximal fragment more internal and distal fragment more external. Four days of skin traction with 30 pounds showed no improvement in position of the femoral fragments. The fracture was manipulated under general anæsthetic. No crepitus could be felt. It was then considered that muscle was interposed between the fragments, which were held apart by the third fragment. Under general anæsthesia again axis traction tongs were applied to the left femoral condyles and strong traction made with manipulation of fragments in an endeavor to obtain reduction without open operation. The leg was put in a Thomas splint with the leg in full extension, and about 20 pounds weight applied to tongs. Three days later a röntgenogram showed the tongs in position on the shaft of the femur about 4 inches above the articular surface of the knee. The overriding was corrected. There was some lateral displacement of the lower fragment, and slight anterior bowing. It was then decided to resort to an open replacement, using the Parnham bands to hold the ends of the fragments together and to use the axis traction tongs, which would permit the leg to be fully extended, together with a Thomas splint for external support. The patient was taken to the operating room in a Thomas hip splint with traction maintained on the tongs. Under general anæsthesia the Thomas splint was removed while traction was maintained on the tongs by an assistant; the fracture was exposed by lateral incision 20 centimetres in length. Interposed muscle fibres were displaced from between the fragments. Contact was apparently normal between the

proximal and distal fragments. The ends of these fragments were placed in contact, and held by two Parnham bands. The middle third fragment was not disturbed with the purpose of avoiding injury to its blood supply and avoiding infection by its proximity to the tongs. The wound was closed and the Thomas splint reapplied. No other support was applied for external fixation other than the Thomas splint with the skeletal traction.

At the end of ten weeks, July 2, 1929, the Thomas splint was removed. Fair union in the femur had taken place. She could raise her limb off bed, and had 15 degrees voluntary knee motion.

August 12, she was discharged from the hospital with a walking splint on left limb made with knee- and ankle-joint to allow motion at these joints and extending up thigh to tuber ischii. Both legs 32½ inches, left knee flexion 50 degrees, hip motion satisfactory. Right ankle in good condition.

This case illustrates a comminuted spiral fracture of the femur which neither skin nor skeletal traction afforded reduction by reason of the interposition of muscle fibres, the intrusion of which was favored by the presence of a complicating third fragment kept the proximal and distal fragments separated. Secondly, the use of a new type of skeletal traction tongs which permits the leg to be fully extended on the thigh. These tongs also have non-pentrating grip, and are prevented from graving out by the broad surface exposed to the cortex of the bone when the points are driven into the bone. The reporter had used these tongs to maintain extension of the leg and avoid the torsional strain which a long lever like the flexed leg might exert on the insecure internal fixation afforded by two Parnham bands as applied in this specific case.

ACUTE SUPPURATIVE ARTHRITIS OF KNEE-JOINT

Dr. Gordon presented a child, aged six years and ten months, who was admitted to the Fifth Avenue Hospital May 17, 1928, with infection of the left knee-joint.

Four days before admission the boy had run a rusty nail into his left knee. He developed a temperature following this with increasing pain and swelling, with a complete loss of function of knee. The child has been in very good health. Fifteen hundred units of tetanus antitoxin were given in clinic. Temperature 101.8°; pulse 90, respirations 24. The left knee-joint was swollen, and contained fluid. There was tenderness on pressure over inner side of medial condyle of femur.

The joint was aspirated and 5 cubic centimetres yellow purulent material withdrawn from knee-joint, which on culture showed staphylococcus albus.

Operation.—Under ether anæsthesia an 8-centimetre incision was made on each side of the patella down to the synovial membrane. The joint was opened into, exposing cul de sac above and interarticular space below. There was a watery, grayish-like pus filling the joint under no great tension. The synovial membrane was œdematous and red, very much congested and swollen. The cartilage was red with deeper red punctate spots. There was no normal-appearing white cartilage seen. The joint was washed out with normal saline solution, and rubber dam strips were laid over edges of incision down to synovial membrane with loose gauze on top. Dry gauze was placed about this, a sterile cotton roll and a compression bandage of gauze were applied. Skin traction was applied to the leg, and the limb elevated in a half ring Thomas splint, three pounds traction weight applied.

Orders for the first night were: (1) Dakin's solution q. 2 h.; (2) voluntary movements of few degrees q. 2 h. under supervision of nurse; (3) trac-

tion to be continuous; (4) elevation of leg above heart. In the evening after operation, the temperature rose to 102°, then fell to 100°. The wound was dressed on the following day, gauze only removed, and a Carrel tube covered with gauze was laid in each incision between the rubber strips, but not into joint, and surface irrigated with Dakin's solution q. 2 h. Dressed daily thereafter.

On the twenty-second wound was examined. There was little discharge, wounds clean and doing well. Child moving knee voluntarily q. 2-3 h. up to 20° without pain. The next day the temperature rose to 101.6°.

On the twenty-third, grayish membrane on surface of soft parts in wound. Treated with 5 per cent. silver nitrate.

On the twenty-seventh, knee doing well. No drainage, and temperature normal. Resisted extension movements of leg instituted. Steady improvement thereafter.

January 21, his wound had healed without crust; he was walking with slight limp. Discharged the next day with 90 degrees flexion. He had been walking for a week.

At follow-up three months later, family stated he returned to school two weeks after leaving the hospital. He had slight tenderness of scar, freely moving patella, and no limitation of motion in knee-joint.

This case illustrated the importance and value of early drainage of an acute suppurative arthritis of the knee-joint, due to an implantation infection, before the articular cartilages have become infected to such a degree that their viability has become destroyed.

TRANSCERVICAL FRACTURE OF NECK OF FEMUR WITH OLD MID-THIGH AMPUTATION

Doctor Gordon presented a man, forty-two years of age, who was admitted to the Fifth Avenue Hospital January 14, 1932, with a fracture of neck of left femur, with old mid-thigh amputation.

During the war, the patient received an injury to left leg which required amputation of limb just about junction of middle and lower third of thigh. He had worn an artificial limb since. On the evening before admission while walking on the street, he stepped on something slippery and fell with the left leg doubled up under him. He was taken home on account of pain in hip and stiffness of the joint. He was brought to hospital the following day.

X-ray films of both hips show a fracture through the neck of the left femur very near the head. There is a slight deformity but the fragments are in good contact, and the appearance is that of some impaction.

Under gas-oxygen and ether, the leg was abducted and put in hyperextension. Internal rotation could not be secured because of the absence of the knee and foot. A modified Whitman spica was applied from high on chest to beyond end of stump on left side. No attempt was made to break up any impaction.

Two weeks later the bandage above right groin was cut away to permit him to sit in a chair. He was up walking on crutches, with which he was familiar, and was discharged to his home to return to the hospital in ten weeks for removal.

March 27, 1930, ten weeks following application of the bandage, he returned for its removal, which was done. Had movement of 45 degrees flexion, extension about 15 degrees, abduction and adduction good without pain. X-ray films of hip showed the fragments in the same position as in previous examination. There is apparently some callus production.

Six months after fracture, he stated at a foliow-up, that five weeks after leaving the hospital he began to walk using artificial leg, with crutches; at five months began weight bearing and walking with crutches. Still uses cane. Can sit in chair naturally. Can abduct left leg 30 degrees, flex thigh 90 degrees.

This case demonstrates the adequacy of repair in a high cervical fracture of the femur with some impaction in a relatively young person, using the Whitman abduction principles in so far as they could be applied, in the absence of the knee and foot to control internal rotation.

GASTROJEJUNAL ULCER AFTER GASTROENTEROSTOMY

Dr. J. William Hinton presented three cases of gastrojejunal ulcer occurring after gastroenterostomy.

GIANT-CELL SARCOMA OF TIBIA

Dr. William B. Coley presented a woman who at the age of twenty-three years was admitted to the Hospital for Ruptured and Crippled in October, 1904, on account of a large, soft swelling over the internal malleolus of one tibia. At operation much reddish-brown, soft material was removed from the lower end of the tibia. The entire lower third of the tibia was apparently involved, and only a thin outer shell remained. The ankle-joint was not involved. Microscopical examination gave the diagnosis as giant-cell sarcoma.

A local recurrence developed and on January 3, 1905, a second curettement was performed followed by prophylactic treatment with toxins and Röntgen-ray. At the time of her discharge from the hospital, five months later, regeneration of bone had taken place in the destroyed area of the lower end of the tibia, and there was a perfect functional result.

At the present time, twenty-eight years later, the patient remains in good condition with no evidence of a recurrence.

A second case presented was a woman who when seventeen years old was admitted to the Hospital for Ruptured and Crippled in August, 1913. An extensive curettement was done followed by tight packing. The wound healed and the cavity filled up without infection. A few days later the toxin treatment was begun, but on account of a severe attack of "grippe" it was discontinued in January. A short while later a recurrent tumor was found at the upper and inner end of the right tibia, at the side of the old sinus. A second curettement was performed. This was followed by a prompt recurrence. One application of the radium pack (12,000 millicurie hours) was given over the site of the tumor, and the toxins were resumed and kept up for a number of months. The patient made a complete recovery and is in excellent health at the present time, seventeen years later.

In this case Doctor Ewing's original diagnosis was that of typical giant-cell sarcoma of the epulis type and of very moderate malignancy. A microscopical section was submitted to Dr. George Barrie, who had made a special study of benign giant-cell tumors, and he reported the condition to be a malignant one. With this opinion Doctor MacCarty of The Mayo Clinic agreed. However, the Bone Sarcoma Registry (see case No. 145) has classified the case as a benign giant-cell tumor.

Doctor Coley said he had presented these two patients because he believed that the problem of the treatment of benign giant-cell sarcoma of the long bones was a most important one, and that there was no unanimity of

opinion among surgeons as to what method of treatment should be employed in an individual case. Paget and Nêlaton, more than eighty years ago, pointed out the benign nature of the majority of giant-cell tumors and advocated conservative measures, their teaching had little permanent influence; up to comparatively recent times amputation remained the method of choice in the great majority of cases.

Doctor Coley believed he had the honor of being the first to advocate the conservative treatment of sarcoma of the long bones exclusive of giant-cell tumors.

Doctor Coley showed lantern slides of two other cases of very extensive giant-cell sarcoma of the femur with involvement of the knee-joint, and of the tibia as well in one case, in which recovery took place, under toxins alone in one case, and under toxins and curettage in the other. In the latter, one radium pack (12,000 millicurie hours) was applied and a steel needle containing 100 milligrams radium was introduced into a small sinus and left there for three hours. This, however, Doctor Coley believes was entirely unnecessary as the patient was apparently cured when the irradiation was begun. A noteworthy feature of this case was the short period of disability, *viz.*, only four months. There was almost complete restoration of function, and the patient remained in good health until eight years later when she died of hæmorrhages from childbirth. Doctor Coley could recall no case in literature of a giant-cell sarcoma of the lower end of the femur with extensive knee-joint involvement that had been cured by anything short of amputation.

EMBRYONAL CARCINOMA OF TESTIS

Dr. Bradley L. Coley presented a man, forty years of age, who was first seen April 16, 1928, when he was admitted to the Hospital for Ruptured and Crippled with a history of having had a painless enlargement of the right testis of five years' duration. It had grown slowly at first but during the past year he felt its increase had been more rapid.

The right half of the scrotum was enlarged to the size of a small grapefruit by a semi-cystic swelling, which was tense and which transilluminated. The testis could not be made out by palpation of the mass. April 17 he was operated upon under ethylene anæsthesia through a scrotal incision. Upon opening the tunica vaginalis the escape of several ounces of bloody fluid revealed an obviously malignant tumor which had replaced the testis. An inguinal incision was then made and the vessels of the cord and vas deferens were clamped high up at the internal ring and the entire mass removed *en bloc*.

The pathological report was embryonal carcinoma of the testis with lymphoid stroma, Grade IV, radiosensitive; it belongs to the type known as seminoma of Chevassu.

The *post-operative treatment* consisted in 152,000 milligram hours of exposure to the radium element pack, using a 6-centimetre portal at 15-centimetre distance; four portals—right abdomen anteriorly, posteriorly, right groin and right scrotum. These treatments were given over a period of five weeks, requiring thirty-eight hours of actual exposure, and were followed seven weeks later by two high-voltage X-ray treatments, one over the right

abdomen anteriorly and one posteriorly. The radium and X-ray treatments were given at Memorial Hospital.

During this seven weeks' interval he was re-admitted to the Hospital for Ruptured and Crippled and given a short, but intensive, course of eleven injections of mixed toxins, ten of which were given intravenously, and seven of which produced pronounced rigors and febrile reactions.

Since July 27, 1928, the date of the last X-ray treatment, he has had no treatment whatsoever and has worked steadily as an investigator for the Department of Education. His weight has remained at or above his previous normal and he has been without symptoms.

OSTEOSARCOMA OF FEMUR

Dr. William B. Coley presented a tumor of the lower end of the femur, which he believed furnished convincing evidence that there are certain benign giant-cell tumors which become transformed into the malignant osteogenic type. The case under discussion occurred in a male, aged twenty-seven years, who was admitted to the Memorial Hospital in June, 1929, with a tumor of the lower end of the femur which had all the clinical and röntgenological features of a benign giant-cell tumor. Röntgen therapy was given for nearly two years under the direction of Doctor Herendeen. The tumor steadily increased in size, and in 1930 a pathological fracture occurred. After a prolonged period of disability, Doctor Coley, in 1931, advised an amputation. To this the patient would not consent. In October, 1931, he consulted Dr. F. H. Albee who believed it would possible to save the limb by conservative operation, that is, curettage with implantation of fat graft. The operation was performed October 21, 1931; the wound healed by primary union, and the patient left the hospital in good condition. Within one month he developed a daily temperature of 102–103°. He returned to the New York Post-Graduate Hospital, where an amputation was performed January 14, 1932. A very large tumor was found to have developed at the site of the curettage, which had involved and completely destroyed the knee-joint. Microscopical examination showed an entirely different type of tumor from the one removed in October, 1931. It was a definitely malignant osteogenic sarcoma with no trace of giant-cell structure. A few weeks later another operation had to be performed for a recurrence in the stump. Röntgenograms taken at this time showed definite evidence of pulmonary metastases. The patient died on April 1, 1932.

FREE FULL-THICKNESS SKIN GRAFT. ITS FIELD OF APPLICABILITY AND TECHNICAL CONSIDERATIONS

Dr. John Garlock read a paper with the above title for which see page 259. The reading of the paper was accompanied with a motion picture demonstration.

Dr. William F. MacFee said there is no question but that the full-thickness graft resembles normal skin more closely than the Thiersch. Its limitations, however, are numerous. It may be used only in clean wounds. Another point is that when one gets a take small areas of necrosis are likely to develop and those little sloughing areas are slow to heal. They are likely to become infected and show a tendency to form keloids. For any place about the face this is a serious disadvantage. The tendency of full-thickness

grafts to become pigmented is important when considered for use about the face.

There is one thing about full-thickness grafts which Doctor Garlock did not mention and that is if buried beneath other tissues the full-thickness graft will nearly always take. The epithelial surface probably derives some nourishment from the overlying raw surface as well as from the raw surface beneath. This vitality of the buried graft is important in the use of pedicle flaps about the face. It is often desirable to have both sides of the pedicle graft covered by skin. By burying the full-thickness graft under the flap one will nearly always get a complete take.

STATED MEETING HELD OCTOBER 12, 1932

The President, Dr. John Douglas, in the Chair

GASTRIC RESECTION WITH INTESTINAL OBSTRUCTION FORTY-EIGHT HOURS LATER

Dr. J. William Hinton presented a man, aged thirty-six years, operated upon at Post-Graduate Hospital June 20, 1932, for a duodenal ulcer with chronic pancreatitis. For ten years previous to admission to the hospital the man had had attacks of epigastric pain, coming on three or four hours after meals; the discomfort was relieved by the intake of food. At the beginning of his trouble he had periodicity with intervals of six to eight months in which he would be free from discomfort. His symptoms had gradually increased in severity and for the past two years he has been under constant medical treatment for an ulcer of the first portion of the duodenum. X-rays taken May 2, 1930, had revealed a duodenal ulcer. In spite of a Sippy régime, Saunder's vaccine intravenously, and gastric mucin, this patient did not obtain symptomatic relief. X-rays November 5, 1930, July, 1931, and April, 1932, had all confirmed the duodenal ulcer. At the time of admission the patient was suffering constant pain in the epigastric region which radiated through to the small of the back.

Operation June 20, 1932, revealed a large duodenal ulcer on the posterior portion of the duodenum which was adherent to the pancreas. The head of the pancreas was enlarged and showed evidence of chronic inflammation with a normal gall-bladder. In view of the pancreatitis a gastric resection was done with an anticolic anastomosis and an enteroenterostomy. After completing the operation the omentum, which was quite heavy, was placed over the suture line, and the abdomen closed. A Levine tube was placed in the stomach. The patient made an uneventful convalescence until forty-eight hours later when it was noticed on irrigating the stomach that there was a definite fecal color to the stomach contents. The patient had no complaints and was in excellent condition, except his pulse had gone from 90 to 130. A diagnosis of high intestinal obstruction was made and the patient observed for another two hours to be sure that the obstruction was complete. At the end of this time a second laparotomy was done. The abdomen was opened through a left rectus muscle-splitting incision and on opening the peritoneum and inspecting the anastomosis between the stomach and the jejunum, and the enteroenterostomy, it was found that the omentum had slid to the left above the transverse colon and in so doing caused a torsion

of the efferent loop of the jejunum, producing a complete obstruction. The omentum was then replaced in its normal position and the abdomen closed.

There was considerable fecal drainage through the Levine tube for the next six hours but after that the irrigations became clear and the patient had an uneventful convalescence.

Dr. Edwin Beer said it was surprising that after extensive gastric operations, and even after gastroenterostomies, that intestinal obstruction due to adhesions to the raw surfaces adjacent to the suture line was not more frequent. Years ago, the patient, after gastric operation, such as gastroenterostomy, frequently had what was called a vicious circle. In those days, extensive gauze protective packs were used during the operation and probably this gauze frequently led to post-operative adhesions about the anastomosis and to ileus caused by the adjacent small intestinal loops becoming plastered onto the anastomosis. In looking over his records, he found two such cases following gastrojejunal anastomoses. Having seen various surgeons make anastomoses between jejunum and stomach in various positions and with various clamps, *etc.*, it is more than likely that the method of anastomosis was not the cause of the so-called vicious circle, as much as secondary adhesions leading to high intestinal obstruction which would produce symptoms suggestive of a vicious circle. The only method of treatment is immediate re-operation, as patients go downhill very rapidly.

GASTROJEJUNAL ULCER WITH CHRONIC PANCREATITIS. RESECTION OF JEJUNUM

Dr. J. William Hinton presented a man, aged forty-one years, who was admitted to the Stomach Clinic of the Fourth Medical and Surgical Divisions of Bellevue Hospital December, 1930, complaining of pain in his back and epigastrium for the past ten years. The patient stated he had been operated upon in the Jersey City Hospital on April 7, 1926, and the report from that institution revealed from X-ray study on March 22, 1926, ptosis of the stomach with an irregular duodenum and ptosis of the transverse colon. At operation April 7, 1926, the stomach, gall-bladder and duodenum were found normal. The appendix was chronically diseased and an appendectomy done. He was not relieved of symptoms following the operation and one year later he was having more distress than before the operation. X-rays taken in April, 1927, revealed a duodenal ulcer. He was treated for this but on March 14, 1930, he had a sudden severe abdominal pain and was taken immediately to the Jewish Hospital in Brooklyn and operated upon for a perforated ulcer. Operative findings in that institution revealed an old indurated pyloric ulcer on the posterior surface perforating into the pancreas. A closure of the perforation was done with a posterior gastroenterostomy.

Following the operation he received relief from his symptoms for only about two months. Since then he has had constant discomfort until coming under the reporter's observation in December, 1930. X-rays taken December 29, 1930, revealed a persistent deformity of the first portion of the duodenum, characteristic of a duodenal ulcer, with a gastroenterostomy of somewhat diminished function but no jejunal ulcer demonstrated. From that date until October 22, 1931, he was receiving Saunder's vaccine intravenously, gastric mucin and a Sippy régime, but in spite of this he got no relief from his

symptoms. X-rays taken in August, 1931, revealed a duodenal deformity characteristic of an ulcer with a normal gastroenterostomy stoma. He then discontinued treatment in the clinic and was under the care of private physicians until September 1, 1932, when he returned complaining of severe abdominal pain which necessitated his having morphine at intervals for several weeks for the relief of his pain. In view of his excruciating pain a diagnosis of jejunal ulcer penetrating into the pancreas, with chronic pancreatitis, was made.

Operation September 9, 1932. On opening the peritoneal cavity numerous adhesions were found, but on inspecting the pylorus and duodenum no evidence of ulceration could be detected, but there was a large penetrating gastrojejunal ulcer on the jejunal side into the pancreas. The stoma was disassociated and the stomach closed, and eight inches of the jejunum resected with an end-to-end anastomosis. The patient made an uneventful convalescence and was discharged fifteen days later.

This patient was presented to illustrate the difficulty in diagnosing marginal ulcers in spite of repeated gastro-intestinal X-ray series. Marginal ulcers are frequently overlooked and one should not rely too much on X-ray studies in reporting cures following gastroenterostomies.

Doctor Hinton presented three cases for the purpose of drawing attention to gastric symptoms being produced by a thyroid deficiency; as there is no evidence of a goitre in these patients the diagnosis is frequently overlooked, and patients of this type are operated upon with unsatisfactory results.

Case I.—Woman, graduate nurse, twenty-eight years of age, first seen in August, 1931, complaining of nausea and vomiting with pain in epigastrium for the past ten years. Her condition is usually worse in the late afternoon, or around 10 to 12 at night. Her past history was negative, but in 1920, at the age of eighteen, she was X-rayed at the Boston City Hospital for a duodenal ulcer and the X-rays were reported as being suspicious. She had followed an ulcer régime for several years, without relief of her symptoms. Before consulting the reporter she had had two gastro-intestinal X-ray series taken at Bellevue Hospital which were reported negative. She stated that she vomited undigested food. Her skin was dry, hair was falling out and she tired easily, and had very little energy until the middle of the day; her symptoms were made worse after a day's work. Physical examination revealed epigastric tenderness with pulse 64, blood-pressure of 100 over 70; a diagnosis of hypothyroidism was made. A basal metabolism done August 28 was a minus 18. The patient was not put on treatment until October 10, 1931, as she left town after the examination. Then she was given thyroxine .60 grain, intravenously, and thyroid extract grains I, T. I. D., by mouth. She was given eight injections of thyroxine, intravenously, at weekly intervals, after which she was greatly improved. November 27, 1931, her basal metabolism was a minus 8, and she was practically free from symptoms, and was not seen again until January 30, 1932. At that time she stated she had been well since her last visit, bothered with nausea only a few times, her hair was greatly improved, and her basal metabolism repeated at that time was a plus 3, but she continued taking thyroid extract daily. March 16, 1932, she was weighing 149 pounds, a gain of ten pounds while under treatment. At this time the patient is about fifteen pounds heavier

than when treatment was started and with the exception of a tired feeling when medication is discontinued she has no complaints.

CASE II.—Male, fifty-nine years of age, seen July 15, 1932, complaining of loss of fifty pounds in weight, vomiting and weakness. *Past History.*—Negative. *Present Illness.*—The patient states that three years ago he began having attacks of nausea and vomiting with some epigastric distress. Attacks have gradually gotten worse and during the past six months he has not worked. Has vomited large quantities of thin watery secretion. Physical examination revealed epigastric tenderness and suspicion of mass in right upper quadrant. Gastro-intestinal series ordered with a diagnosis of carcinoma of the pylorus, but the X-rays were reported negative. The patient had no symptoms referable to a thyroid deficiency but a basal metabolism was ordered as a means of ruling out a hypothyroidism. The first test was unsatisfactory, and on August 4, 1932, his test revealed a minus 22. He was put on thyroxine intravenously, at weekly intervals, and thyroid extract grains I, T. I. D. and since treatment was started he has been free from symptoms and feels perfectly well and has gained about seven pounds in weight. A basal metabolism done on September 28 was a plus 13. Thyroxine has been discontinued and he is now taking thyroid extract by mouth.

CASE III.—Male, aged sixty-two years, first seen in March, 1932, complaining of nausea and vomiting and a burning sensation in upper abdomen which was relieved by the intake of food. *Past History.*—Negative. *Present Illness.*—Patient states he has had a burning sensation in abdomen for the past four years and that this has been gradually getting worse and for the past several months he has had constant abdominal discomfort with nausea and vomiting which has incapacitated him from work and during this time he has lost fifteen pounds. A gastro-intestinal series done at Bellevue Hospital was negative for a gastric or duodenal ulcer but a basal metabolism done March 18 revealed a minus 19. The patient was then put on thyroxine intravenously, at weekly intervals, and thyroid extract grains I, T. I. D. He began to show improvement and for the past four months has been symptom-free. To date he has had seventeen injections of thyroxine, and has continued thyroid extract by mouth. Basal metabolism done on October 5 was a plus 23. At this time he weighs 118½ pounds, as against 104 pounds when treatment was started. Thyroxine has been discontinued and he is taking only two grains of thyroid extract daily.

These patients will have to continue thyroid medication but after the basal metabolism has been raised to normal with thyroxine, intravenously, it is much easier for them to be kept in balance by oral administration. Patients suffering from hypothyroidism frequently do not absorb thyroid satisfactorily when administered orally and that is the reason for using thyroxine intravenously.

JEJUNOSTOMY FOR GASTRIC ULCER

DR. HUGH AUCHINCLOSS presented a man, forty-four years of age, first seen by him December 21, 1931. He came for relief of long-standing indigestion. He did not appear seriously ill. His brother had a gastric ulcer and his mother died of carcinoma. In 1922, he began to have digestive symptoms, and this year his gall-bladder and appendix were removed at Lebanon Hospital. In 1924, his symptoms returned. At various times under gastric lavage, milk, cereal, toast and simple diet, he had been greatly relieved. About June, 1930, his symptoms began to be more persistent. He was unable

to work because of a pain that came on irregularly, not only before, but after meals, beginning in his left lower chest, chiefly in his epigastrium, and radiating to the lower abdomen, ending up low down in his back. The pain was very severe. It was not relieved by taking food, but when on a careful diet he had less of it. He was chronically constipated and had gaseous eructations, nausea, and occasional vomiting.

In 1930, X-ray studies at the Presbyterian Hospital showed a small gastric residue, but no other evidence of pathology in the gastro-intestinal tract. Just previous to admission in December, 1931, a crater of considerable size was demonstrated on the lesser curvature, indicative of ulcer of the stomach.

December 30, 1931, a partial gastrectomy and a post-colic gastroenterostomy with a jejunoduodenostomy and a jejunostomy were done. At the end of a rather long operation his blood-pressure was 120 and his condition good. A Murphy button was used in doing the jejunoduodenostomy. The button was passed the twenty-seventh day after operation.

Sterile 5 per cent. glucose was given to him through the jejunostomy opening for two weeks. At first the tube was left unclamped but later was clamped for varying periods of time. Up to 1,200 cubic centimetres of fluid a day were taken in this way. His stomach was washed three times during the first week because of hiccough. Incidental to this there was a separation of the wound edges without visceral protrusion. Although this prolonged his stay in bed it was not of particular significance. This has, however, given rise to a post-operative hernia.

PAGET'S DISEASE OF BONE MISTAKEN FOR METASTATIC CARCINOMA

Dr. Morris K. Smith presented a man of sixty-one years who entered St. Luke's Hospital in January, 1930, in care of Dr. H. G. Bugbee, for hypertrophied prostate. Fifteen days after a first-stage suprapubic cystostomy, while he was being helped into a chair, his left thigh snapped. X-ray examination showed a pathological fracture of the left femur with bone changes, as later determined, also in the pelvis, sixth dorsal vertebra, and right humerus, thought to be those of metastatic carcinoma. The skull was not involved. Although the prostate did not suggest malignancy to palpation it was assumed to be the focus and the advisability of going through with the second stage of the operation was questioned. Meanwhile, the fracture was put up in suspension and traction. In two months union was sufficiently firm to allow the patient up in a chair. A month later the prostate was removed by Doctor Bugbee. The pathological report was adenomatous hyperplasia with no evidence of malignancy. The patient left the hospital in May, four months after admission, cured of his prostatic disease and walking with a brace.

Despite the proved innocent character of the prostatic enlargement the fear that he was suffering from malignancy involving the bones still persisted at the time of his discharge. The further progress of his case, however, has ruled this out, and established the diagnosis of osteitis deformans. In the period of two and one-half years since leaving hospital the patient has gained weight and remained well. There is no shortening of the leg and he walks without a limp. A recent X-ray showed the appearance of the involved bones to be approximately the same.

This case was presented to emphasize the difficulty that may arise in the differentiation of Paget's disease and metastatic carcinoma of bone. The reporter referred to an article by Carman and Carrick of The Mayo Clinic

(Collected Papers, vol. xii, p. 1160, 1920), in which they cite fifteen cases of Paget's disease, four of whom were diagnosed by X-ray as metastasis in bone. They state that "the osteoplastic type of metastasis is the one condition that may easily be mistaken from the X-ray standpoint for an osteitis deformans."

When a typical case of Paget's presents, with skull and long bone involvement, the diagnosis is simple, based upon the clinical picture and the X-ray findings, but when the disease is limited to one bone, the diagnosis may be almost impossible. In the X-rays shown by Doctor Smith, the eburnation of the body of the vertebra is more suggestive of carcinoma, whereas pictures of the pelvis and long bones seem more suggestive of Paget's disease; possibly both are combined in this particular patient.

Dr. Howard Lilienthal said that he thought the clinical course had considerable significance in the diagnosis. This man is walking about, perfectly well, the picture of health, so that it does not seem there can be any question of the correctness of Doctor Smith's diagnosis.

Doctor Smith, in closing the discussion, replied to Doctor Bancroft that he had examined the patient's neck carefully more than once hoping to find evidence of an enlarged parathyroid gland but with negative result. A calcium determination made on the serum was 13 milligrams, phosphorus 3.4 milligrams. The calcium output in one twenty-four-hour urine specimen was 360 milligrams.

CYSTS OF EXTERNAL SEMILUNAR CARTILAGE

Doctor Smith presented a man, thirty-seven years old, on whom he had operated for cystic tumor of the external semilunar cartilage in May, 1925. A swelling had appeared on the outer side of the right knee four years before. There was no history of trauma. For the past year there had been pain and disability. Examination revealed a swelling on the outer side of the knee one and one-half inches in diameter. Flexion of the knee was limited to 90°. The thigh on the involved side measured one inch less than its fellow. At operation the tumor was found to be tensely compressed beneath the fascia and attached to the external cartilage of the joint. In cutting it away a yellowish discoloration of tissue was noted similar to that found in the tumor itself, suggesting that the disease may have extended into the cartilage. The cartilage was not removed. On section the tumor was made up of multiple cysts with gelatinous content.

The patient was relieved of his symptoms following the operation and was presented before this Society five months later at the meeting of October 14, 1925. There had not been an opportunity to examine him previous to the presentation, although he had reported himself well. He had at this time a recurrence of tumor at the original site in spite of his symptomatic and functional recovery.

On examination at the follow-up clinic ten months after operation it was found that the tumor was larger than ever before. Although he had no complaints the operation was considered a failure.

Seventeen months after the operation the tumor had decreased markedly

in size. At two years a small cystic mass the size of a finger nail remained and at two and one-half years a small mass was still found.

At the next examination three and one-half years subsequent to operation it had disappeared, and at the last examination in December, 1931, six and one-half years after operation, was still absent.

Instances of recurrence necessitating a second operation when the cartilage was not removed at the original intervention have been reported.

JEJUNOSTOMY—A CLINICAL AND EXPERIMENTAL STUDY OF THE TECHNIC

Dr. William Howard Barber read a paper with the above title for which see page 553.

Dr. Allen O. Whipple said there were certain points in connection with the topic of the evening which he wished to discuss. The first was in regard to the technic, especially in cases where jejunostomy is done as a temporary measure. As a permanent measure Doctor Barber's method would have greater advantages over the tube method. In regard to bringing the jejunum up to the abdominal wall the speaker differed with Doctor Auchincloss. His feeling in regard to the making of a temporary jejunostomy is that this should be as simple as possible and he was glad to see from Doctor Barber's presentation that the Kader produces less obstruction than the Witzel. It has been his practice to insert a rubber catheter, suturing the tube into the edges of the opening in the jejunum and then tying the purse-string suture fairly snug. He does not tie it too tight for fear of interfering with the normal blood supply which is a great safeguard. He never uses omentum as it does not build up barriers around the jejunum. One has to trust the peritoneum to take care of the barriers to be built up against leakage. He has seen severe fistula follow bringing the jejunum up to the abdominal wall. He had been interested in going over the post-mortem findings in cases in which jejunostomy had been done since the Presbyterian Hospital moved up to 168th Street. There have been seven cases so examined during the last four years in which jejunostomy was used and the patients came ultimately to autopsy. In none did peritonitis result from the jejunostomy. One died of hæmorrhage where the incision was made in the left rectus. It is his custom to use a pericostal incision near the outer border of the rectus. In none was there peritonitis or death occurring from leakage. In none of these cases was the jejunostomy a factor in hastening the end. There was one interesting thing: that was the red, congested appearance of the jejunum to which Doctor Barber alluded, and in one case multiple ulcers were present.

Dr. Seward Erdman said that he believed that too many jejunostomies had been performed in the past but surgeons are now learning the limitations as well as the proper indications for their use. Regarding the animal experiments reported by Doctor Barber, he was surprised to see that leakage had occurred into the peritoneal cavity in a number of instances, within the short space of two days, where the Stamm-Kader method and an omental

flap had been used, and the abdominal wall closed about the tube. Such an occurrence would constitute a serious menace to the patient. Irrespective of whether omentum has been used or not, one would expect that the snug suturing about the tube in the intestinal wall would keep it watertight for more than two days.

On the Second Division of the New York Hospital, they have used the Witzel method almost exclusively and the wound is left open except for closure of the peritoneum.

The rubber tube is not sutured to the gut at any point, but may be fastened to the skin by one loose suture, to aid in retention.

The Witzel suture line is fastened by one suture to the parietal peritoneum. Even very early, if indicated by non-drainage, one may safely clear the tube by gentle syringe irrigation, and without leakage for several days. In any event the leakage will come out of the wound, avoiding contamination of the peritoneum.

As the tube is not sutured to the intestinal wall, it may be readily shifted, by slight rotation, or pushed a bit farther in, or partially withdrawn, without disturbing its function.

Usually the tube has served its purpose and can be withdrawn in about five days, after which there is practically no leakage and the wound closes promptly by granulation.

Dr. Henry F. Graham commented on the fact that nothing had been said regarding the suture material used. That is a very important factor. In operating in the different hospitals one has to use the material at hand. In one an atraumatic suture is used, the purpose being to get away from the loop in the eye of the needle. The speaker once had a bad case of obstruction in this hospital where plain suture material was used. The patient died and the pathologist thought the peritonitis was most marked around the site of the jejunostomy. One should use either chromic or silk of some kind. Doctor Graham said he did not use an ordinary catheter because it does not drain properly. He prefers to use a tube the same size as a catheter with a few openings in the side and one on the end because this causes more easy drainage. He has noted that the cases which drain profusely for the first twenty-four hours are the ones that get well and the ones that do not drain do not get well.

Dr. Howard Lilienthal said he did not know what method Doctor Barber used during operation to block the gut, but he was firmly convinced, as he has frequently expressed himself before this Society, that a large piece of rubber dam with a small hole punched in the middle makes the best occlusion for the loop of gut during the operation. The little hole is stretched by the operator, or an assistant, while a generous loop of gut is drawn through it and the rubber sheet is permitted to contract thus isolating the part to be operated upon. Nearly all his jejunostomies have been performed for obstruction combined or not with peritonitis. He also uses a fine tube

instead of a catheter because the lumen of the tube compared with the outside measure is greater than that of the usual thick-walled catheter. He has always used the Witzel method in the small intestine and he anchors the tube to the opening in the gut by a single suture of fine catgut. This gut disappears in two or three days so that there is no trouble in moving the tube. Doctor Lilienthal, however, does not often move the tube from its position but if stoppage takes place he injects a little air or water through the tube for relief. He does not angulate the gut by suturing it to the parietal peritoneum. Should leaking occur later on there is no cause for alarm for by that time a sinus will have formed and the leaking material does not contaminate the surrounding healthy parts. He has always advised that jejunostomy should precede resection of the thoracic œsophagus because œsophagogastrostomy can then be performed by drawing the stomach up into the mediastinum through an enlarged opening in the diaphragm. This would be difficult or impossible if gastrostomy had been performed instead of jejunostomy. Fine silk is better than catgut in many of Witzel's operations because it takes longer to cut through the gut wall and eventually disappears. Doctor Eliot once showed a specimen in which, at post-mortem years after a large intestinal resection with hundreds of silk ligatures, not a single stitch remained.

Dr. Hugh Auchincloss said that he believed if in doing a jejunostomy one let the gut go back very far there are risks run quite as great as if the gut is brought close to the abdominal wall. Although Doctor Barber argues that the leakage is greater, Doctor Auchincloss felt he would rather have any leakage occur near the wall than in the abdominal cavity. Besides, if they are made properly and no drainage required in the wound, they do not leak. The small fistulæ that occur when the tube is removed close promptly. Furthermore, it would seem preferable to have one loop of intestine with an adhesion to the anterior abdominal wall where it is easy of access if ileus subsequently did develop than several coils adherent to one another deeper in the peritoneal cavity. Emphasis should be made upon its use as a prophylaxis against obstruction. If one is going to use it one should do so early. The second thing is in regard to what one should put in a jejunostomy. If one has to put in fluids it is well to put in sterile, and very bland fluids. Five per cent. glucose is the best and next salt solution. In regard to the tube, it is the speaker's practice to make six or seven holes in the tube with a punch and for suture material he uses fine catgut crimped on the end of the needle.

Doctor Barber, in closing the discussion, said that he had thought the modified technic, using the flap, combined the advantages Doctor Whipple had brought out together with the advantages of having the stomatized loop close to the abdominal wall. The sutures were protected by fresh peritoneum and the loop and flap were covered by omentum. This overlying omentum saved the jejunal loop from harmful adhesions. In answer to Doctor Erdman regarding the leakage occurring within two days, the speaker explained

that it was the very early changes going on about the tube in the intestinal loop: the seepage of digestive secretions from between the sutures or the fibrelike adhesions (represented in the drawings), that were of special interest. In certain of the experiments fine streams of digestive fluid giving a fiery-red appearance to the peritoneum and especially to the omental fat were observed within forty-eight hours. The presence of these currents of leaking fluid seemed to make impossible the formation of adhesions. The omentum confined the irritating intestinal fluid for a few hours but by the third day pools of blood-stained fluid were observed in such cases in the left lumbar gutter or pelvis. In regard to suture material, the speaker used fine chromic gut with needle attached. The question of drainage had been brought up, and in this regard Doctor Barber was in accord with Doctor Graham, who said that the cases that drain well early do well. Doctor Lilienthal's idea of using rubber dam in the place of intestinal clamps was new to the speaker and he thought he would try it in the future. He, too, did not favor the use of intestinal clamps.

STATED MEETING HELD OCTOBER 31, 1932

The President, Dr. John Douglas, in the Chair

OSTEOMYELITIS OF THE SKULL

Dr. Grant P. Pennoyer presented a child, ten years old, who, on September 7, was taken ill with an intense headache and a temperature of 105°. A reddened, swollen, well-demarcated area of inflammation was on the centre of her forehead. She was kept in bed nine days with marked improvement. An area of fluctuation then appeared in the forehead into which was made a small incision on September 18, 1932. A profuse discharge of pus was obtained, which continued. When it was attempted to irrigate the cavity, the irrigating fluid came out of her nose. The patient's eyes and forehead, at times, became very œdematous, and the patient was referred to the hospital. This patient had had very little trouble with colds and nasal discharge, and no apparent rhinitis or respiratory infection just before the onset of this illness. She was admitted to the Roosevelt Hospital October 13, 1932. She seems quite well except for the remarkable local condition. She has no fever, no headache, and the leucocyte count is 10,500, 68 per cent. polymorphonuclears. The Wassermann reaction is negative. The X-ray shows extensive osteomyelitis of the frontal bone extending almost to the coronal suture. The frontal sinuses are not yet developed. She seems to have some haziness in the right antrum and the ethmoidal sinuses. The Nose and Throat Department express the opinion this osteomyelitis is a result of a pan-sinusitis. A subcutaneous abscess appeared recently, and, when opened, gave exit to a small flat sequestrum. Cultures show *Staphylococcus aureus*. Conservative treatment is being adopted, opening subcutaneous abscesses as they appear. Her case is presented to illustrate the paper of the evening.

Doctor Pennoyer presented also a colored woman, fifty-seven years old, as the subject of osteomyelitis of the frontal bone. In August, 1931, a fluctuant, rather tender abscess appeared on her left upper frontal region just at the hair line. She had no fever and little pain. Incision and drainage

were done in the Out-Patient Department September 7, 1931. She has been returning ever since at frequent intervals for dressings. As the wound continued to drain, it was curetted in October, 1931, with the idea of removing any possible remaining cyst wall. A roughening of the underlying frontal bone was noted. The Wassermann reaction was negative. The wound became larger, and a few small sequestra were extruded. X-rays taken in March, 1932, showed an area of decreased bone density of the frontal bone in this region. A second Wassermann was negative, and the reaction was also negative after a provocative dose of neo-salvarsan. A prolonged course of iodides and mercury by mouth failed to give any improvement. The lesion progressed so that the meninges could be seen pulsating in the base of a deep punched-out wound which was about two and one-half centimetres across. Cultures showed *Staphylococcus aureus* and no fungi or higher forms of bacteria. Biopsy of the tissue showed simple inflammatory granulation tissue. A recent X-ray shows the process well demarcated and she is now about healed. Three X-ray-therapy treatments given last September seemed to have helped her considerably. This is apparently a primary chronic osteomyelitis of the frontal bone.

SARCOMA OF THE LOWER EXTREMITY
Well After Five Years

Dr. Grant P. Pennoyer presented a woman, forty-five years of age, who was admitted January 7, 1926, to the Roosevelt Hospital with a three-months' history of a rapidly growing tumor on the left thigh. She recalls an injury to this region about four months before which was considered of no consequence. The tumor was hard, was attached to the muscles and measured about seven by four centimetres. There were no palpable lymph-nodes of any size, and blood Wassermann examination, X-ray of chest and general examination yielded no further helpful information. Instead of simple excision, a more thorough operation was done. Careful examination of the location of the tumor in relation to the muscular anatomy established the fact that the growth lay in the superficial adductors of the thigh. Instead of dissecting right down on the tumor, a wide excision of the skin and fat over the tumor was done. The sartorius, gracilis, and adductor longus muscles were divided near their origin, far above the upper limit of the tumor, and the cleavage planes of their deep surface followed downward to well below the region of the tumor. This allowed removal of the tumor along with the underlying fasciæ and muscles, and the overlying tissue and skin, all in one piece with no manipulation in the immediate region of the neoplasm.

The pathological report by Dr. Wm. C. White is as follows: "The specimen consists of a firm, fibrous mass, poorly encapsulated, seven by four by four centimetres, along with a considerable amount of muscle, fat, and overlying skin. There is a definite invasion of the muscle by the tumor tissue. Sections show a very immature, cellular fibrous tissue with large and irregularly shaped nuclei. Some of the nuclei are vesicular, others hyperchromatic. Mitotic figures are abundant. Some regions are very cellular, in others the nuclei are isolated in fibrous tissue."

Diagnosis.—Spindle-cell fibrosarcoma. Doctor Ewing made the diagnosis of very malignant neurogenic sarcoma. The slides were again reviewed by Doctor Ewing and Doctor Stewart of the Memorial Hospital and by the pathologist of Roosevelt Hospital, Dr. Sophian. All agree recovery from this type of tumor is very rare. The patient is apparently well, and it is now almost

seven years since her operation. The loss of these muscles has caused no impairment in function.

A man, aged thirty-five years, was admitted to Roosevelt Hospital August 1, 1927, having a painless, slightly tender, rather soft mass in his right popliteal fossa which had been definitely growing for nine months. It was rather fixed to the deep soft parts but had no attachment to the skin. At operation it proved to be a peculiar multilocular cystic process imbedded in the soft tissue of the popliteal fossa and definitely invading the outer head of the gastrocnemius muscle. The cysts contained clear gelatinous material. A seemingly thorough excision was done. It recurred promptly. He was readmitted to the hospital February 20, 1928, and again excised. At this operation a much longer incision was made sacrificing the skin over the tumor. The outer head of the gastrocnemius muscle was divided at its origin and its deep surface followed downward a considerable distance below the tumor. This made it possible to remove the tumor with it and the overlying skin and fat all in one piece without any dissection in the immediate region of the diseased tissue.

The pathological report by Dr. Wm. White and confirmed by Dr. James Ewing was a myxosarcoma. The central portion of the tissue was infiltrated by a soft gelatinous tissue giving the appearance of multiple, small, thin walled cysts. Microscopical sections show the muscle infiltrated with a myxomatous material not very cellular. In places are embryonic connective-tissue cells lying in a meshwork of delicate and coarse fibrils which stain blue. The cells vary widely in shape and size. There are no mitotic figures.

This is not nearly so malignant a tumor as the former case, but it is definitely malignant. He was given a series of three prophylactic treatments of X-ray therapy. About a year later the patient thought he had a recurrence in his scar and applied to another hospital where the tissue was excised, but no tumor tissue was found. This was confirmed by Dr. Francis Carter Wood. They also gave him some radium treatment. He has remained well to date.

These two cases emphasize the fact that by study of the anatomical relations of a malignant tumor of the soft parts, it may be possible to remove that tumor with the underlying muscles and fasciæ and the overlying fat and skin all in one piece without any dissection or trauma in the immediate region of the tumor.

In breast surgery local excision of a malignant tumor is recognized as even worse than useless and we remove the whole region with its underlying muscles and fasciæ in which lies the lymphatic circulation. The same principle is applicable to the extremities. The lymphatic circulation of a region follows largely the fascial planes of the muscles which are removed by this type of operation. Equally important is the lack of trauma to the immediate tumor region.

Dr. George H. Semken remarked that in operations upon malignant new growths of the lower extremities, the bloodless field is of great advantage, but the use of the Esmarch bandage, the tourniquet, or even the Sehrt apparatus is open to the objection that tumor plugs in the lymphatic or blood-vessels may be dislodged by the pressure and may produce distant metastases (as

against purely local recurrence or regional metastasis alone). An alternative in producing a relative ischæmia is the exposure of the femoral artery in the groin, and its control by traction-angulation with a temporary, untied ligature. The ligature is placed distal to the three upper superficial branches. The collateral circulation, via branches of the internal and external iliac arteries (mainly the superior and inferior gluteal branches of the internal iliac), will not cause troublesome bleeding during the excision operation. The long ends of the ligature are allowed to emerge from the sutured wound, and the ligature is removed at the end of the desired period of ischæmia, to restore the full blood supply. It is desirable to have the assistant that will later control the artery determine the amount of traction necessary to angulate the artery without injuring it, by practising this before this wound is closed. A safe method is the grasping of the ends of the ligature with a hemostat, which is then held by its handle between the thumb and middle finger as a fulcrum, while the index finger elevates the tip and exerts the necessary gentle traction upon the ligature. Meanwhile the ulnar edge of the hand rests upon the patient's thigh. The exposure of the femoral artery in the groin gives access also to the inguinal lymph-nodes for inspection or for probatory excision if indicated.

The polymorphic variations in sarcoma cases are well illustrated in the wide differences in histological structure shown in the slides of Doctor Pennoyer's two patients. These variations are more easily understood by a study of the genetic constitution of the tumor tissue. Sarcomata are tumors of mesoblastic origin. Contrary to the common belief, the mesoblast is not merely embryonal connective tissue, but, beginning as an epithelial cell group, it later retains the epithelial character in its middle segment and part of its lateral segment, and differentiates in its remaining portion, into the embryonal connective tissue. The epithelial elements form the primordia for the kidneys, adrenal cortex, and other structures. The embryonal connective tissue furnishes the primordia not alone for the skeletal and connective tissues but also for the spleen, the vascular structures and other tissues—sharing thus in the construction of nearly all of the body. An important fact in development is that all these cells may retain in latent form potentialities not brought out in the process of differentiation. [A. Fischel.]

To trace the genetic constitution of the sarcomatous tumor tissue, it is necessary to begin with the embryonic start of the type of tissue involved. Normal tissue has the three potentialities of growth, function, and differentiation. In tumor tissue, function and differentiation are either absent or variably limited, leaving the metabolic energy wholly or in greatest part for the potentiality of growth. The increased growth rate is thus readily understood. The degree of differentiation may be anything from zero to fairly advanced specialization and the morphology of the tumor will then show any of the grades of variation from undifferentiated fetal cells or fetal connective tissue through the respective stages representative of the development of those tissues in their usual normal course. Myxomatous

tissue is like fetal connective tissue. In carcinoma, the epiblastic ancestry limits the range of morphological variation and early cancers can be recognized. The mesoblast, however, both allows wide differences in morphology and does not make the beginnings of the sarcomata distinct from tissue changes due to other causes. Remnants of the function-potential, when present, may produce structural modifications. Further changes are produced, in the picture, by inflammatory changes and the incidents of tumor experience, notably autolysis and trauma.

Concerning the etiology, the frequency with which sarcoma follows a definite single trauma at the site of tumor growth apparently bears out Ribbert's theory of tumor genesis, namely, the splitting off [Absprengung] and isolation of small tissue groups, which then begin an independent growth. This is not the continued, uncontrolled growth of fully differentiated adult cells, but the emergence of germinal potentialities previously latent in that group.

The neurogenical sarcomata are not of necessity of a more malignant type than the sarcomata in other tissues. The nerves are formed from two germinal layers; the axial nerve fibres and the cells of the nerve sheaths are derived from the epiblast, and the remaining elements are derivatives of the mesoblastic connective tissue. The genetic disturbance in the latter may result in tumor growth varying from simple neurofibroma to a malignant type of fibrosarcoma; and the disturbance may be limited or extensive. The epiblast is not necessarily involved in the primary disturbance. The cause of the differences in the grade of malignancy is probably to be found, in largest measure, in the degree of embryonic abnormality.

EXCISION AND SKIN GRAFT FOR LARGE VARICOSE ULCER

Doctor Pennoyer presented a woman, fifty-three years old, to illustrate the cure of large chronic varicose ulcers by excision of the whole area, including the deep fascia, and immediate skin graft. He showed two cases of this before the society last year. The theory is that removing all the thickened scar-like deep fascia, the region receives a new blood and lymphatic circulation from the deep tissues. He had used Thiersch grafts and had obtained good results right over bare tendons, periosteum and muscle tissue. The elephantiasis and œdema in these extremities is usually much improved by this new source of lymphatic and venous drainage.

The woman now presented had had extensive ulceration and swelling of her right leg for years. She had been treated in their Out-Patient Department for two years by the injection treatment, the usual round of medications and local pressure with large rubber sponges and bandages, all without improvement. At the time of her admission she had two enormous ulcers involving most of the anterior half of her right leg associated with extensive elephantiasis. Wide excision was done March 21, 1932, after a period of two weeks' rest in bed and sterilization of the ulcers with Dakin solution. The wound produced in this case by the total excision of the area and its underlying thickened, scar-like deep fascia formed a huge excavation in the bottom of which lay exposed about eight inches of the tibia, the bare tendons and muscle bellies of all the extensor muscles of the foot and toes, and a large area of the posterior muscles. Fortunately, she had a large thigh, from

which to obtain Thiersch grafts. The grafts were held fixed by firm pressure obtained by using a large, flat, rubber sponge and the wound was not disturbed for one week. The "take" was almost 100 per cent. and she was discharged, healed, May 2, 1932. Last August a slight trauma associated with the macerating action of a wet, perspiration-soaked dressing caused a minor ulceration which healed on rest in bed. This procedure is well worth keeping in mind in cases of chronic varicose ulcer associated with œdema and elephantiasis which will not respond to simpler treatments.

Dr. Fenwick Beekman said that it was unfortunate that attempt was not more frequently made to heal these varicose ulcers by operative measures. Doctor Pennoyer's principle of skin grafting is very important; that is, before it is performed there must be a base to lay the graft on which has sufficient blood supply to nourish the graft. Many attempts have been made to skin graft by laying the graft on the base of the ulcer and they have not taken. Even when they have taken they have not formed good skin. The principle which should be carried out is the excision of all scar tissue down to deep fascia. As to the question of lymphatic drainage, Doctor Beekman took exception to the statement of Doctor Pennoyer that by reëstablishing this the elephantiasis and œdema of the extremity are much improved. He could not see how, by placing a layer of epidermal tissue on the skin, one could reëstablish lymphatic circulation. Of course, by getting rid of the scar tissue the lymphatics may be enabled to grow, but he could not see how new lymphatics could be laid down to drain the ulcer.

HABITUAL DISLOCATION OF THE SHOULDER. THE NICOLA OPERATION

Dr. Henry F. Graham presented a man, twenty-four years of age, who, in 1928, fell and dislocated his left shoulder. It was reduced and remained well for three months and then became again dislocated. Since that time innumerable dislocations have taken place—even raising the arm would cause a dislocation. When admitted to the Methodist Hospital May 8, 1932, he stated that the shoulder had been out more than thirty times.

The operation described by Toufick Nicola was performed May 9, 1932. The steps are as follows: an incision is made along the outer side of the coracoid process and down the anterior border of the deltoid muscle for a distance of four inches. The pectoralis major is retracted inward and the deltoid outward, exposing the long head of the biceps up to its origin. The transverse humeral ligament is divided and the tendon of the biceps lifted out of the bicipital groove. The capsule of the joint is then opened in line with the tendon.

Next the tendon is cut about one inch above the muscle fibres—leaving sufficient good tendon for subsequent suture. A one-fourth-inch hole is then drilled through the head of the humerus beginning just below the transverse humeral ligament and coming out at the centre of the articular surface of the head. The elbow is flexed and a probe is passed through the drill hole and, by the aid of a silk suture, the upper end of the tendon is drawn down through and resutured to the lower end with silk. The capsule and transverse humeral ligament are sutured with catgut.

A Velpeau bandage is applied with the elbow flexed and maintained for

two weeks. Limitation of motion is prevented by complete abduction of the arm before sewing up.

When seen September 27, 1932, this patient had had no dislocation of the shoulder since operation. Motion seems nearly perfect. There is a slight limitation of abduction after the horizontal is reached.

Dr. Russell H. Patterson said that he had done this operation on six cases with excellent results. Doctor Nicola has operated on twenty-seven such cases without a recurrence. The operation is very useful also where there is a fracture of the surgical or anatomical neck of the humerus with or without disclocation of the head. The drill hole may be brought down through the two fragments and the tendon will thus hold the fragments well in place. One of Doctor Nicola's patients died from an accident five months after the operation and an autopsy was secured. Doctor Nicola found that the tendon was firmly attached to its new home and the tendon was a little larger than normal. The tendon is supposed to become attached to the bone and not glide through the new canal. When the operation was first done the tendon was brought out through the middle of the head of the humerus, but now that Doctor Nicola is bringing the tendon out through the upper third of the head of the humerus, this causes less buckling of the tendon. The biceps tendon is very strong, its tensile strength is 6,900 pounds per square inch. It takes on an average of 240 pounds to break the tendon. The incision we now use is placed midway and at right angles to the line drawn from the tip of the acromion process to the tip of the coracoid process. The incision need not be more than three inches long.

THREE GASTROENTEROSTOMIES IN THE SAME PATIENT WITH INTESTINAL OBSTRUCTION FOR AN INTERLUDE

Dr. Henry F. Graham presented a man, aged thirty-four years. Years ago this patient had various attacks of pain coming on four or five hours after meals, situated in the epigastrium and relieved by soda or food. A diagnosis of duodenal ulcer was made. After a period of good health his symptoms recurred while living in Singapore. He returned to this country and a gastroenterostomy was performed in 1925. A duodenal ulcer was found at operation.

He was well for a time but eventually his same symptoms returned and gradually became worse until 1930 when a second gastroenterostomy was performed by the same surgeon.

After a few months of comfort he began again to have abdominal pain of a severe colicky nature accompanied this time by nausea. There were a number of these attacks which finally culminated on August 25, 1931, in a very intense, excruciating pain with violent vomiting. He was admitted to the Methodist Hospital on that day with an abdomen slightly distended, tense, symmetrical and slightly tender in the epigastrium. Auscultation gave a little gurgling. The Wassermann test was negative. Blood count showed over 5,000,000 red cells, 95 per cent. hæmoglobin, 8,900 white cells and 86 per cent. polymorphonuclears.

An X-ray examination and Rehfuss test were omitted because the patient was in too great pain. A gastrojejunal ulcer was considered and there was a delay of three days hoping for improvement but he became worse. The

abdomen became distended, vomiting persisted and hiccough commenced. The tinkling sounds in the abdomen also increased.

August 29 operation under neocaine intraspinally. A loop of jejunum was found united to the posterior wall of the stomach through the transverse mesocolon about three feet from the ligament of Treitz. No patent stoma could be found between the two. Coils of small intestine had slipped through the opening left by the long loop and a volvulus had occurred. The proximal gut was much distended.

The old anastomosis was separated. The opening in the jejunum was sutured with three rows of sutures and covered by a free omental graft, because the peritoneum was absent. A new posterior no loop gastroenterostomy was made. The most distended loop of bowel above the obstruction was drained by a jejunostomy tube which was brought out through a separate stab wound.

Convalescence was smooth. The temperature and pulse were elevated to 102° and to 120 per minute respectively for four days and then steadily declined. There was no post-operative vomiting. The distension rapidly disappeared and the jejunostomy tube drained profusely for seven days when it was removed. A small abscess developed in the upper end of the wound seventeen days after operation. This was opened and promptly healed. The patient was discharged one month after operation.

In the next two months he gained twenty pounds in weight. He occasionally has a little heartburn or intestinal colic but these attacks promptly subside and seem to be due to indiscretion in diet.

October 5, 1932, he reports that he is well. His weight has remained normal.

APPENDICITIS FOLLOWED BY LIVER ABSCESS AND SUPPURATIVE PLEURISY

Dr. Henry F. Graham presented a man, twenty-six years of age, who was admitted to the Methodist Hospital May 20, 1931. He had been suffering from abdominal pain for one week. This was located in the right upper quadrant of the abdomen, was steady, non-radiating and was made worse on exertion.

There was no nausea nor vomiting. Examination showed tenderness in the right upper quadrant without rigidity. No mass was present.

Operation two days later under spinal anæsthesia revealed an angry red appendix which was removed. The gall-bladder was normal.

Following this operation the temperature remained high and by the eighth day had reached 103°. A blood count at this time showed 4,090,000 red cells; 70 per cent. hæmoglobin; 23,100 leucocytes and 79 per cent. polymorphonuclears. An X-ray negative of the chest showed no abnormality of lung or diaphragm except an elevation on the right side.

On the tenth day after the appendectomy portions of the ninth and tenth ribs were removed in the right axillary line. The pleural cavity was opened and the upper surface of the diaphragm palpated. A hard, smooth, round mass was felt in the top of the liver in the nipple line.

The pleura was sutured to the diaphragm around the edge of the wound and the skin was marsupialized also. The wound was packed with gauze.

Four days later a trocar was passed through the wound into the liver and pus was obtained at a depth of one and a half inches. An electric cautery was passed along the trocar and a large rubber tube inserted.

Subsequent to the liver drainage the general condition of the patient

improved, but a week later a pleurisy with effusion appeared and aspiration obtained a little serosanguinous fluid. Five days after the aspiration there was a profuse discharge of thin yellow fecal-smelling pus from the thoracotomy wound. It was then necessary to maintain both liver and pleural drainage.

A week after this a transfusion of 500 cubic centimetres was given. A Dakin's tube was inserted into the pleural cavity and irrigations of Zonite 1 in 3 were given.

July 7, 1931, there was still a large cavity present in the thorax. A month later the X-ray showed fluid in the pleural cavity and pus was aspirated. A pyo-pneumothorax was present at this time.

The patient left the hospital September 3, 1931, after an illness of fourteen weeks. He was improving rapidly but there was still a discharging wound. September 27, 1932, a year later, his weight was normal and he was in perfect health except for a small sinus one and a half inches in length which did not communicate with bone or pleura and had practically no discharge.

An X-ray picture a few days later showed slight thickening of the pleura and practically normal lung expansion and marking. The diaphragm was slightly elevated upon the right side.

AVULSION OF THE SKIN ABOUT THE ELBOW

Dr. Gaston A. Carlucci presented a woman, thirty years of age, who was admitted January 20, 1931, to Columbus Hospital Extension with a history of having been knocked down and dragged by an automobile.

On admission she was unconscious, suffering from severe shock and nearly pulseless. Her injuries, as far as could be determined then, were two severe lacerations of the left frontal region and an extensive dirty laceration of the left upper extremity, the skin and subcutaneous tissues having been torn completely off above the elbow and stripped down to about the middle of the forearm. There were several lacerations in the muscles, particularly along the inner aspect and what appeared to be a torn cutaneous nerve was dangling loose at the side.

External heat was applied, a clysis was given, and then a continuous intravenous infusion of warm saline for about four hours, the patient absorbing about 5,000 cubic centimetres during that time. The arm was cleansed as well as possible and then a continuous warm saline dressing applied. The elbow-joint itself did not seem to be injured, and although the internal epicondyle was exposed, clinically no fracture could be made out—which later was corroborated by X-ray.

The patient rallied and gradually came out of her shock. The avulsed skin was brought up as far as possible to cover the exposed muscles and the saline dressing was continued for several days when it was changed to Dakin's solution as the edges of the skin flaps began to necrose.

This treatment was continued, adhesive straps were applied to keep the skin flaps from retracting and the devitalized parts removed from time to time. She coöperated very well and she was encouraged to flex her elbow, the wound finally becoming a clean granulating one.

About two months after the accident Thiersch grafts were applied over the raw area and most of them remained viable. The small bare areas gradually became epithelialized and the whole wound healed. The function of the elbow gradually returned so that now there is practically no limitation of any of the motions.

MALUNION OF FOREARM FRACTURE

Dr. Fenwick Beekman thought that more attention should be given to healing these open areas, for the more rapid the healing the less scar tissue forms and less deformities will occur. Splinting of arms and using traction to prevent deformity, like other older methods, are *passé*. The way to prevent contractures is to cover the surface of the wound with skin and the earlier this is done, the more pliable will be the scar and the less the contracture. If one examines Doctor Carlucci's case, he will see that the graft is as soft and pliable as the skin surrounding it, because Doctor Carlucci succeeded in healing the wound at a time before much granulation tissue had formed, for granulation tissue always precedes scar tissue.

MALUNION OF FOREARM FRACTURE

Dr. Carlucci presented a man, fifty-five years of age, who was knocked down by an automobile June 1, 1932. He was treated in a hospital where a plaster case was applied and two weeks later a splint. He was seen by the reporter about five weeks after the accident. At that time he had a marked œdema of the hand and forearm, there was a decided bowing at the middle of the forearm, and he could not supinate or pronate his hand even the slightest degree without severe pain.

Radiographs taken at this time showed a double fracture of the ulna, the one at the lower third overriding about two centimetres. The radius had a single fracture at the junction of the upper and middle third with overriding of the fragments, one of them being quite close to the ulna. On account of the bowing and the possibility of a beginning cross union between the radius and ulna the condition was operated upon.

The fracture of the radius was exposed first. The callus was found firmly attached to the ulna. This was loosened and as it was impossible to overcome the overriding, about two centimetres of the bone were resected from one of the fractured ends and a Lane plate with four screws applied and the wound closed. The lower fracture of the ulna was then exposed and here again about two centimetres of the upper fragment removed with its spicules and the two ends brought together and wired. A sugar-tong plaster splint was applied and the forearm held in suspension with a bandage. There was no post-operative reaction, the patient leaving the hospital on the sixth day post-operative, the wounds healing by primary union.

OSTEOMYELITIS OF THE SKULL

Dr. Ira Cohen read a paper with the above title for which see May issue of Annals of Surgery.

BRIEF COMMUNICATIONS

MUSCLE PACK TO CONTROL HÆMORRHAGE FROM THE LIVER

DURING the course of a cholecystectomy for an abscessed gall-bladder the anterior superior surface of the liver was pierced by the blade of an abdominal retractor and a large excavation resulted, the control of the hæmorrhage from which presented an unusual problem. (Figs. 1 and 2.) Mattress sutures had always been used to close tears in the edges of the liver and the cautery for raw bleeding surfaces. When faced with this large excavation in the anterior surface of the liver suturing seemed impossible, and the hæmorrhage was so violent that cauterization seemed impracticable so packing with a hot sponge was the only means at hand to temporarily control the bleeding.

While operating in the adjoining room to a brain surgeon a few days before this occurrence a request had been received for muscle to control hæmorrhage. With this in mind a large chunk of the rectus muscle was taken and stuffed into the opening in the liver; and the liver was elevated against the abdominal wall where it was held firmly during the rest of the operation for cholecystectomy. The hæmorrhage stopped so that upon the completion of the operation the injured area in the liver was dry and a firm clot had formed, filling over the excavation in the liver and enclosing the muscle pack. The clot and muscle were left undisturbed and the abdomen closed.

During the next eighteen months several biopsy specimens were taken from the liver by cutting out a wedge of tissue from the anterior surface and filling the hole with muscle tissue upon which pressure was made for four to six minutes or until a solid clot formed to fill the hole and enmesh the muscle tissue. The biopsy specimens obtained in this way have been more satisfactory than those obtained from the liver's edge, and there has been no difficulty in controlling hæmorrhage with the muscle tissue.

The regenerative power of the liver has been very well shown when the first patient in which this procedure was used was again operated upon eighteen months later for a stone in the common duct. At the second operation the region in which the former accident had occurred was inspected and there was not the least vestige of evidence of scarring nor adhesion formation.

Attention should be called to this accident also as it might happen to anyone when doing a cholecystectomy under spinal anæsthesia that the patient may inhale or sigh deeply, forcing the liver down suddenly upon the sharp edge of a retractor, which acts like a hoe to chop out a portion of liver substance. (Fig. 1.) The assistant had lowered the handle of the retractor which brought the edge of the blade out from the abdominal wall and left the sharp edge poised above the liver. Right angle retractor blades

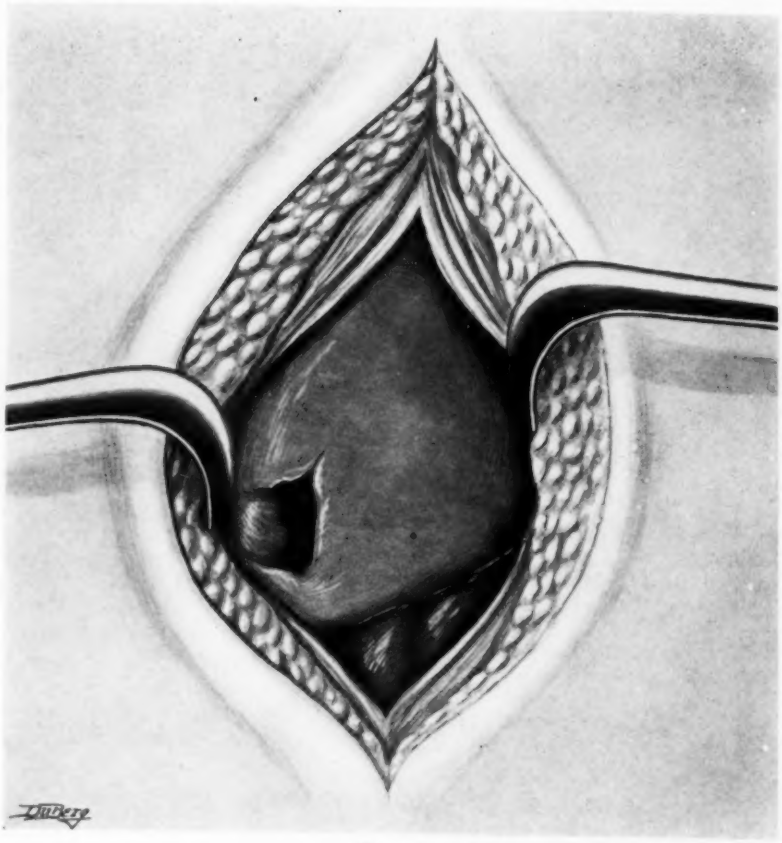

FIG. 1.

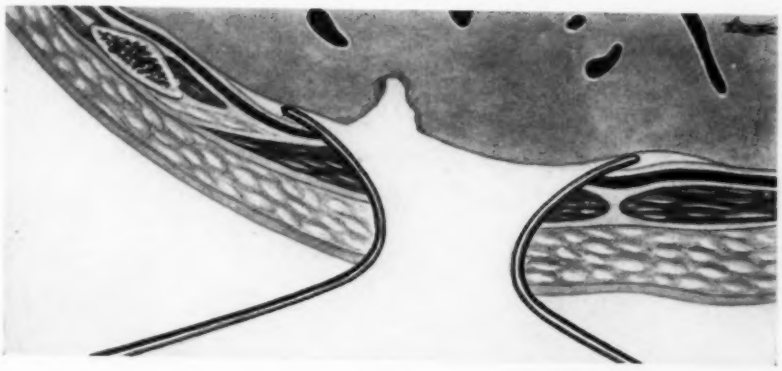

FIG. 2.

FIGS. 1 and 2.—Showing the excavation in the anterior surface of the liver made by the retractor edge upon forced inspiration with the patient under spinal anæsthesia

are especially likely to do this, therefore one should be careful to have retractors of this sort made at an acute angle so the blade will hug closely the inner surface of the abdominal wall.

R. FRANKLIN CARTER, M.D.
New York, N. Y.

FIG. 1.—Condition when first seen at age of three weeks.

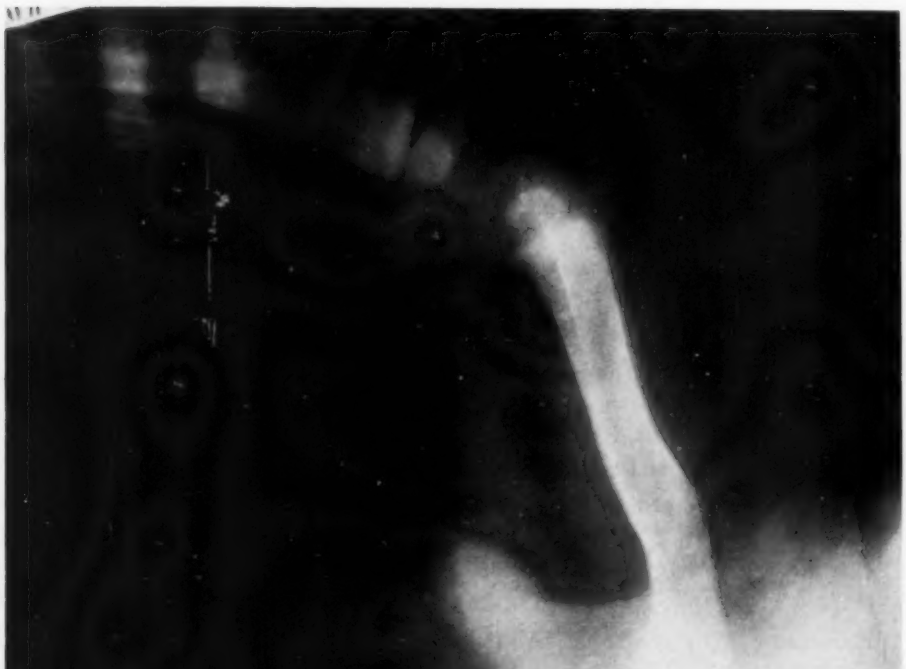

FIG. 2.—Lateral view nine weeks later.

SPONTANEOUS CORRECTION OF BIRTH FRACTURE DEFORMITY

THE tendency toward restoration of form in fractures in young children is widely known but the following case report and X-ray pictures are an object lesson in conservatism. That I had judgment enough to advise as I did I owe to Dr. E. D. Truesdell, of New York, who first pointed out to me the incredible powers of restoration of form birth fractures show. Truesdell's experience is set forth in Scudder's Treatment of Fractures in the chapter on birth fractures. None of the femur fractures cited there recovered so rapidly or completely as this one.

A three-weeks-old infant was brought with a badly angulated and shortened left thigh due to a fracture of the shaft of the femur at birth. Some effort had been made at overhead suspension but this was soon abandoned on account of the irritation of the skin of the leg and ankle.

Examination showed a marked swelling, anterior bowing and shortening of the thigh. The skin of the thigh was badly irritated from adhesive plaster. They had a poor X-ray which (retouched) is reproduced here. (Fig. 1.) Under the fluoroscope considerable callus was seen and there was firm fixation which could scarcely be budged. The parents were anxious for *immediate operative correction*. The condition of the skin, the age of the infant and the magnitude of the undertaking in one so young precluded this. I told them I thought a good leg would result without any intervention. They finally promised not to let anything be done to the baby for six weeks and then return. They came back exactly nine weeks later. (Fig. 2.) Grossly the injured leg could not be recognized. X-rays showed the injured leg as long as the sound one and the form almost restored. Certainly no operative procedure could have done any better.

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MESENTERIC CYST OBSTRUCTING BOWEL

INTESTINAL obstruction due to a mesenteric cyst is uncommon. Of 103 cases of obstruction of the bowel observed at the University of Kansas Hospital the case here reported is the first which was due to a mesenteric cyst. Of the various types of mesenteric cysts (serous, chylous, sanguinous, hydatid, dermoid, malignant, entero- and embryocystomata), it can be said that the cystomata are very frequently associated with intestinal obstruction, while the chylous cysts are infrequently associated with obstruction. The occurrence of intestinal obstruction with dermoid cysts is somewhat more frequent than with chylous cysts. Of six cases of mesenteric cyst at this hospital, some of which were found at autopsy, there were three cystomata, one chylous, one serous, and one in which the type was not stated. Only the case reported, an enterocystoma, produced an intestinal obstruction.

CASE REPORT.—Male, aged twenty-two, was admitted to the University of Kansas Hospital, complaining of pain in the abdomen, constipation and vomiting. His bowels had not moved for six days, although he had taken numerous cathartics. Vomiting and abdominal pain of a cramp-like nature began five days before admission. The patient said he had been vomiting ten to fifteen times a day. He complained of severe thirst and had been drinking much water since the onset of his illness. There was a history

of several previous attacks similar to this during the past eight years, but cathartics had given him relief.

On examination, peristalsis could be seen. His abdomen was somewhat tender. Rectal examination suggested a mass in the pelvis. His white count was 27,100 with 89 per cent. polymorphonuclear leucocytes. The blood chlorides were 230 milligrams per 100 cubic centimetres of blood, the carbon dioxide combining power was 76.8 per cent., the urea nitrogen 94.6 milligrams, and the creatinine 1.8 milligrams.

The patient was given intravenous sodium chloride solution immediately and shortly afterward a Witzel enterostomy was done. At operation the bowel was found distended and discolored. The cause of the obstruction was not determined. Due to distention a second enterostomy was done twelve hours later. There was no peritonitis found at

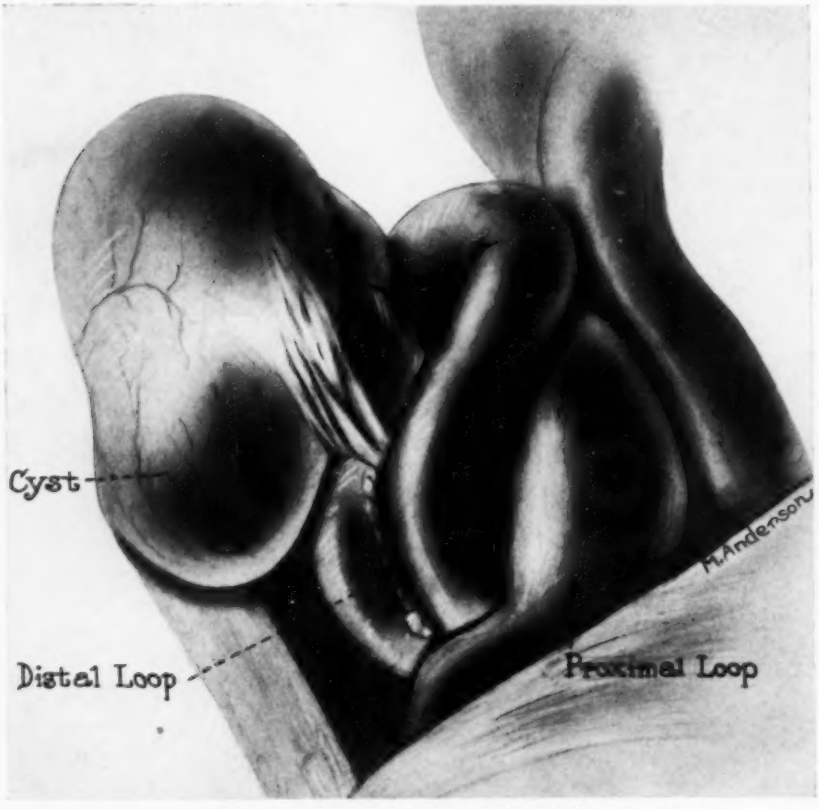

FIG. 1.—Cyst of the mesentery with volvulus of ileum in situ.

either operation. He died eight hours later. At autopsy a cyst of the mesentery near its enteric attachment, 50 centimetres from the ileocæcal valve, was found. (Fig. 1.) The cyst measured 12 by 8 by 6 centimetres and was filled with a gelatinous material. The intestine had been twisted two or three times on itself but was not strangulated. A perforation of one of the loops of intestine near the obstruction, with a generalized peritonitis, accounted for the patient's death.

Microscopical examination of the wall of the cyst showed a structure analagous to the intestine with a layer of columnar epithelium, three fairly distinct muscle layers and a serosa. Histological diagnosis was enterocystoma.

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